

HW 1 Report

Installation of Virtual Machine on Windows

1. To install virtual machine on QEMU, I installed QEMU first on windows and set the environment variable for QEMU
2. Then I installed the Windows subsystem for Linux and Ubuntu LTS from the Microsoft store.
3. On WSL, I created Ubuntu image with partition size

```
sudo qemu-img create ubuntu.img 10G -f qcow2
```

4. I downloaded disk image for UBUNTU and ran

```
sudo qemu-system-x86_64 -hda ubuntu.img -boot d -cdrom  
./ubuntu-20.04.5-live-server-amd64.iso -m 2046 -boot strict=on
```

5. This started the QEMU with the Ubuntu installation guide.

6. After the installation I ran

```
sudo qemu-system-x86_64 -hda ubuntu.img -boot d  
-m 2046 -boot strict=on
```

The above command started the ubuntu terminal

To know the configuration I ran lscpu command. This started with 1 CPU.

```
QEMU - Press Ctrl-Alt to exit mouse grab
jil@ubuntu:~$ 
jil@ubuntu:~$ lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Byte Order:            Little Endian
Address sizes:         40 bits physical, 48 bits virtual
CPU(s):                1
On-line CPU(s) list:  0
Thread(s) per core:   1
Core(s) per socket:   1
Socket(s):             1
NUMA node(s):          1
Vendor ID:             AuthenticAMD
CPU family:            6
Model:                 6
Model name:            QEMU Virtual CPU version 2.5+
Stepping:               3
CPU MHz:               2304.000
BogoMIPS:              4608.00
Virtualization:        AMD-V
L1d cache:             64 Kib
L1i cache:             64 Kib
L2 cache:              512 Kib
L3 cache:              16 Mib
NUMA node0 CPU(s):     0
Vulnerability Itlb multihit: Not affected
Vulnerability L1tf:      Not affected
Vulnerability Mds:       Not affected
Vulnerability Meltdown: Not affected
Vulnerability Mmio stale data: Not affected
Vulnerability Retbleed:  Not affected
Vulnerability Spec store bypass: Vulnerable
Vulnerability Spectre v1: Mitigation; usercopy/swapgs barriers and __user pointer sanitization
Vulnerability Spectre v2: Mitigation; Retpolines, STIBP disabled, RSB filling, PBRSB-eIBRS Not affected
Vulnerability Srbds:     Not affected
Vulnerability Tsx async abort: Not affected
Flags:                  fpu de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 s
                           syscall nx lm nopl cpuid pnpi cx16 hypervisor lahf_lm svm 3dnop prefetch vmmcall
```

When adding `"-smp 2` it started the server with 2 CPU

```
QEMU
See "man sudo_root" for details.

jil@ubuntu:~$ [ 83.056209] cloud-init[945]: Cloud-init v. 22.2-0ubuntu1~20.04.3 running 'modules:config' at Fri, 27 Jan 2023 2:44:54 +0000. Up 80.95 seconds.
[ 88.011914] cloud-init[951]: Cloud-init v. 22.2-0ubuntu1~20.04.3 running 'modules:final' at Fri, 27 Jan 2023 22:45:00 +0000.
Up 86.80 seconds.
[ 88.016137] cloud-init[951]: Cloud-init v. 22.2-0ubuntu1~20.04.3 finished at Fri, 27 Jan 2023 22:45:01 +0000. Datasource Data
SourceNone. Up 87.96 seconds
[ 88.022737] cloud-init[951]: 2023-01-27 22:45:01,900 - cc_final_message.py[WARNIN]: Used fallback datasource

jil@ubuntu:~$ lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Byte Order:            Little Endian
Address sizes:         40 bits physical, 48 bits virtual
CPU(s):                2
On-line CPU(s) list:  0,1
Thread(s) per core:   1
Core(s) per socket:   1
Socket(s):             2
NUMA node(s):          1
Vendor ID:             AuthenticAMD
CPU family:            6
Model:                 6
Model name:            QEMU Virtual CPU version 2.5+
Stepping:              3
CPU MHz:               2303.997
BogoMIPS:              4607.99
Virtualization:        AMD-V
L1d cache:             128 KiB
L1i cache:             128 KiB
L2 cache:              1 MiB
L3 cache:              32 MiB
NUMA node0 CPU(s):    0,1
Vulnerability Itlb multihit: Not affected
Vulnerability L1tf:    Not affected
Vulnerability Mds:    Not affected
Vulnerability Meltdown: Not affected
Vulnerability Mmio stale data: Not affected
Vulnerability Retbleed: Not affected
Vulnerability Spec store bypass: Vulnerable
Vulnerability Spectre v1: Mitigation: usercopy/swapgs barriers and __user pointer sanitization
Vulnerability Spectre v2:  Mitigation: Retpolines, STIBP disabled, RSB filling, PBRSB-eIBRS Not affected
Vulnerability Srbds:   Not affected
Vulnerability Tsx async abort: Not affected
Flags:                 fpu de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 s
                      yscall nx lm nopl cpuid pnpi cx16 hypervisor lahf_lm svm 3dnopprefetch vmmcall
jil@ubuntu:~$
```

Before we move forward with Experimental results let's see the system configuration of both windows and virtual machine so that it can help us understand the performance evaluation

System info of Windows

```
jil@Jil:~/Downloads$ inxi -Fx
System: Host: Jil Kernel: 5.15.79.1-microsoft-standard-WSL2 x86_64 bits: 64 Desktop: N/A
          Distro: Ubuntu 18.04.6 LTS
Machine: No /sys/class/dmi; using dmidecode: root required for dmidecode
CPU: 8 core 11th Gen Intel Core i7-11800H (-MT-MCP-) arch: N/A cache: 24576 KB
      flags: (lm nx sse sse2 sse3 sse4_1 sse4_2 ssse3 vmx) bmips: 36864
      clock speeds: max: 2304 MHz 1: 2304 MHz 2: 2304 MHz 3: 2304 MHz 4: 2304 MHz 5: 2304 MHz 6: 2304 MHz
      7: 2304 MHz 8: 2304 MHz 9: 2304 MHz 10: 2304 MHz 11: 2304 MHz 12: 2304 MHz 13: 2304 MHz 14: 2304 MHz
      15: 2304 MHz 16: 2304 MHz
Graphics: Card-1: Microsoft Device 008e bus-ID: 03f7:00:00.0
           Card-2: Microsoft Device 008e bus-ID: 4dff:00:00.0
           Display Server: wayland (X.org 12.1 ) drivers: dxgkrnl,dxgkrnl Resolution: 2560x1600@59.99hz
           OpenGL: renderer: llvmpipe (LLVM 10.0.0, 256 bits) version: 3.3 Mesa 20.0.8 Direct Render: Yes
Network: Card: Failed to Detect Network Card!
Drives: HDD Total Size: 552.3GB (1.8% used)
        ID-1: /dev/sda model: Virtual_Disk size: 0.4GB temp: 0C
        ID-2: /dev/sdb model: Virtual_Disk size: 2.1GB temp: 0C
        ID-3: /dev/sdc model: Virtual_Disk size: 274.9GB temp: 0C
        ID-4: /dev/sdd model: Virtual_Disk size: 274.9GB temp: 0C
Partition: ID-1: / size: 251G used: 7.6G (4%) fs: ext4 dev: /dev/sdd
           ID-2: swap-1 size: 2.15GB used: 0.00GB (0%) fs: swap dev: /dev/sdb
RAID: No RAID devices: /proc/mdstat, md_mod kernel module present
Sensors: None detected - is lm-sensors installed and configured?
Info: Processes: 17 Uptime: 2:40 Memory: 2426.3/7826.3MB Init: N/A Gcc sys: N/A
      Client: Shell (bash 4.4.201) inxi: 2.3.56
jil@Jil:~/Downloads$
```

System of VM Ubuntu

```
jil@ubuntu:~$ inxi -Fx
System: Host: ubuntu Kernel: 5.4.0-137-generic x86_64 bits: 64 compiler: gcc v: 9.4.0 Console: tty 1
          Distro: Ubuntu 20.04.5 LTS (Focal Fossa)
Machine: Type: Qemu System: QEMU product: Standard PC (i440FX + PIIX, 1996) v: pc-i440fx-bionic
          Serial: <superuser/root required>
          Mobo: N/A model: N/A serial: N/A BIOS: SeaBIOS v: 1.10.2-1ubuntu1 date: 04/01/2014
CPU: Topology: 2x Single Core model: QEMU Virtual version 2.5+ bits: 64 type: SMP arch: K7 Palomino+ rev: 3
      L2 cache: 1024 KIB
      flags: lm nx pae sse sse2 sse3 svm bogomips: 4607
      Speed: 2304 MHz min/max: N/A Core speeds (MHz): 1: 2304 2: 2304
Graphics: Device-1: vendor: Red Hat driver: bochs-drm v: N/A bus ID: 00:02.0
           Display: server: No display server data found. Headless machine? tty: 128x48
           Message: Advanced graphics data unavailable in console. Try -G --display
Audio: Message: No Device data found.
Network: Device-1: Intel 82371AB/EB/MB PIIX4 ACPI vendor: Red Hat Qemu virtual machine type: network bridge
           driver: piix4_smbus v: N/A port: c040 bus ID: 00:01.3
           Device-2: Intel 82540EM Gigabit Ethernet vendor: Red Hat QEMU Virtual Machine driver: e1000 v: 7.3.21-k8-NAPI
           port: c000 bus ID: 00:03.0
           IF: ens3 state: up speed: 1000 Mbps duplex: full mac: 52:54:00:12:34:56
Drives: Local Storage: total: 10.00 GiB used: 4.16 GiB (41.6%)
        ID-1: /dev/sda vendor: QEMU model: HARDDISK size: 10.00 GiB
Partition: ID-1: / size: 8.02 GiB used: 4.06 GiB (50.6%) fs: ext4 dev: /dev/dm-0
           ID-2: /boot size: 1.69 GiB used: 105.7 MiB (6.1%) fs: ext4 dev: /dev/sda2
Sensors: Message: No sensors data was found. Is sensors configured?
Info: Processes: 103 Uptime: 19m Memory: 1.94 GiB used: 211.3 MiB (10.7%) Init: systemd runlevel: 5 Compilers: gcc: N/A
      Shell: bash v: 5.0.17 inxi: 3.0.38
jil@ubuntu:~$
```

Experiment results for VM

CPU Performance

Scenario 1

In scenario 1 we have set the test-cpu-prime value to 10000. This means the CPU performance will be tested until the processor verifies the prime number till 10000.

Below are the experimental results

Test case 1

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 612.95

General statistics:
  total time:          10.0028s
  total number of events: 6134

Latency (ms):
  min:                 1.52
  avg:                 1.61
  max:                 48.57
  95th percentile:    1.73
  sum:                9900.64

Threads fairness:
  events (avg/stddev):   6134.0000/0.00
  execution time (avg/stddev):  9.9006/0.00

Test case: 2
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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!
```

Test case 2:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 614.23

General statistics:
total time: 10.0017s
total number of events: 6146

Latency (ms):
min: 1.51
avg: 1.61
max: 51.36
95th percentile: 1.76
sum: 9912.10

Threads fairness:
events (avg/stddev): 6146.0000/0.00
execution time (avg/stddev): 9.9121/0.00

Test case: 3
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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!
```



Test Case 3:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 625.96

General statistics:
total time: 10.0018s
total number of events: 6263

Latency (ms):
min: 1.49
avg: 1.59
max: 48.11
95th percentile: 1.76
sum: 9953.26

Threads fairness:
events (avg/stddev): 6263.0000/0.00
execution time (avg/stddev): 9.9533/0.00

Test case: 4
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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!
```



Test case 4:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 624.21

General statistics:
total time: 10.0027s
total number of events: 6246

Latency (ms):
min: 1.49
avg: 1.58
max: 49.71
95th percentile: 1.76
sum: 9891.28

Threads fairness:
events (avg/stddev): 6246.0000/0.00
execution time (avg/stddev): 9.8913/0.00

Test case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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!
```

Test case 5:

```
QEMU - Press Ctrl-Alt to exit mouse grab
total time: 10.0027s
total number of events: 6246

Latency (ms):
min: 1.49
avg: 1.58
max: 49.71
95th percentile: 1.76
sum: 9891.28

Threads fairness:
events (avg/stddev): 6246.0000/0.00
execution time (avg/stddev): 9.8913/0.00

Test case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 618.77

General statistics:
total time: 10.0021s
total number of events: 6191

Latency (ms):
min: 1.48
avg: 1.61
max: 50.98
95th percentile: 1.79
sum: 9957.46

Threads fairness:
events (avg/stddev): 6191.0000/0.00
execution time (avg/stddev): 9.9575/0.00

jii@ubuntu:~$
```

Scenario 2:

Same as scenario 1 I just changed the value of cpu-max-prime to 30000.

Test case 1

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!

CPU speed:
  events per second: 148.09

General statistics:
  total time:          10.0038s
  total number of events: 1482

Latency (ms):
  min:                 6.44
  avg:                 6.73
  max:                48.96
  95th percentile:    7.04
  sum:                9976.74

Threads fairness:
  events (avg/stddev): 1482.0000/0.00
  execution time (avg/stddev): 9.9767/0.00

Test Case: 2
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!
```



Test case 2:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!

CPU speed:
events per second: 148.11

General statistics:
total time: 10.00020s
total number of events: 1482

Latency (ms):
min: 6.42
avg: 6.70
max: 53.02
95th percentile: 7.17
sum: 9930.14

Threads fairness:
events (avg/stddev): 1482.0000/0.00
execution time (avg/stddev): 9.9301/0.00

Test Case: 3
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!
```



Test case 3

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!

CPU speed:
events per second: 147.52

General statistics:
total time: 10.0016s
total number of events: 1476

Latency (ms):
min: 6.44
avg: 6.76
max: 51.83
95th percentile: 7.30
sum: 9976.17

Threads fairness:
events (avg/stddev): 1476.0000/0.00
execution time (avg/stddev): 9.9762/0.00

Test Case: 4
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!
```



Test case 4

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!

CPU speed:
events per second: 146.02

General statistics:
total time: 10.0058s
total number of events: 1463

Latency (ms):
min: 6.46
avg: 6.82
max: 51.80
95th percentile: 7.30
sum: 9977.40

Threads fairness:
events (avg/stddev): 1463.0000/0.00
execution time (avg/stddev): 9.9774/0.00

Test Case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!
```



Test case 5

```
QEMU - Press Ctrl-Alt to exit mouse grab
total time: 10.0058s
total number of events: 1463

Latency (ms):
    min: 6.46
    avg: 6.82
    max: 51.80
    95th percentile: 7.30
    sum: 9977.40

Threads fairness:
    events (avg/stddev): 1463.0000/0.00
    execution time (avg/stddev): 9.9774/0.00

Test Case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!

CPU speed:
    events per second: 148.77

General statistics:
    total time: 10.0049s
    total number of events: 1489

Latency (ms):
    min: 6.42
    avg: 6.70
    max: 48.09
    95th percentile: 7.17
    sum: 9975.94

Threads fairness:
    events (avg/stddev): 1489.0000/0.00
    execution time (avg/stddev): 9.9759/0.00
jili@ubuntu:~$
```



Scenario 3:

In scenario 3 I sat the value of cpu-max-prime = 50000

Test case 1:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!

CPU speed:
events per second:    75.84

General statistics:
total time:          10.00038s
total number of events: 759

Latency (ms):
min:                  12.76
avg:                 13.15
max:                 60.49
95th percentile:     13.70
sum:                9981.82

Threads fairness:
events (avg/stddev):   759.0000/0.00
execution time (avg/stddev):  9.9818/0.00

Test case: 2
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!
```



Test case 2:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!

CPU speed:
events per second:    74.99

General statistics:
total time:          10.0098s
total number of events: 751

Latency (ms):
min:                  12.79
avg:                 13.23
max:                 20.07
95th percentile:     13.95
sum:                9933.08

Threads fairness:
events (avg/stddev):   751.0000/0.00
execution time (avg/stddev):  9.9331/0.00

Test case: 3
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!
```



Test case 3:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!

CPU speed:
  events per second:    75.48

General statistics:
  total time:          10.0122s
  total number of events: 756

Latency (ms):
  min:                  12.82
  avg:                 13.21
  max:                 54.50
  95th percentile:     13.95
  sum:                 9987.49

Threads fairness:
  events (avg/stddev):   756.0000/0.00
  execution time (avg/stddev):  9.9875/0.00

Test case: 4
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!
```



Test case 4:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!

CPU speed:
events per second:    74.78

General statistics:
total time:          10.0123s
total number of events: 749

Latency (ms):
min:                  12.87
avg:                 13.34
max:                 48.99
95th percentile:     14.21
sum:                9992.21

Threads fairness:
events (avg/stddev):   749.0000/0.00
execution time (avg/stddev):  9.9922/0.00

Test case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!
```



Test case 5:

```
total time:          10.0123s
total number of events: 749

Latency (ms):
min:                  12.87
avg:                 13.34
max:                 48.99
95th percentile:     14.21
sum:                9992.21

Threads fairness:
events (avg/stddev):   749.0000/0.00
execution time (avg/stddev):  9.9922/0.00

Test case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000
Initializing worker threads...
Threads started!

CPU speed:
events per second:    75.48

General statistics:
total time:          10.0122s
total number of events: 756

Latency (ms):
min:                  12.76
avg:                 13.20
max:                 60.60
95th percentile:     13.95
sum:                9977.58

Threads fairness:
events (avg/stddev):   756.0000/0.00
execution time (avg/stddev):  9.9776/0.00

ii@ubuntu:~$
```



File IO Testing

Scenario 1

We are testing this for 2G files

Below are the test case result

Test case 1

```
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          579.84
  writes/s:         386.55
  fsyncs/s:        1239.88

Throughput:
  read, MiB/s:      9.06
  written, MiB/s:   6.04

General statistics:
  total time:           30.0369s
  total number of events: 66153

Latency (ms):
  min:                  0.14
  avg:                 0.44
  max:                 54.45
  95th percentile:     0.75
  sum:                29109.15

Threads fairness:
  events (avg/stddev): 66153.0000/0.00
  execution time (avg/stddev): 29.1092/0.00
```

Test case 2:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          541.37
  writes/s:         360.92
  fsyncs/s:        1158.68

Throughput:
  read, MiB/s:      8.46
  written, MiB/s:   5.64

General statistics:
  total time:       30.0400s
  total number of events: 61800

Latency (ms):
  min:                 0.14
  avg:                 0.47
  max:                16.06
  95th percentile:    0.86
  sum:               29092.17

Threads fairness:
  events (avg/stddev): 61800.0000/0.00
  execution time (avg/stddev): 29.0922/0.00
```

Test case 3:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          548.96
  writes/s:         366.00
  fsyncs/s:        1171.62

Throughput:
  read, MiB/s:      8.58
  written, MiB/s:   5.72

General statistics:
  total time:       30.0372s
  total number of events: 62561

Latency (ms):
  min:                 0.14
  avg:                 0.47
  max:                15.66
  95th percentile:    0.83
  sum:               29138.62

Threads fairness:
  events (avg/stddev): 62561.0000/0.00
  execution time (avg/stddev): 29.1386/0.00
```

Test case 4:

```
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          542.49
  writes/s:         361.68
  fsyncs/s:        1161.21

Throughput:
  read, MiB/s:      8.48
  written, MiB/s:   5.65

General statistics:
  total time:       30.0801s
  total number of events: 62025

Latency (ms):
  min:              0.14
  avg:              0.47
  max:             22.67
  95th percentile: 0.87
  sum:            29076.80

Threads fairness:
  events (avg/stddev):    62025.0000/0.00
  execution time (avg/stddev): 29.0768/0.00
```



Test case 5:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          612.18
  writes/s:         408.12
  fsyncs/s:        1305.98

Throughput:
  read, MiB/s:      9.57
  written, MiB/s:   6.38

General statistics:
  total time:       30.0773s
  total number of events: 69868

Latency (ms):
  min:                 0.14
  avg:                 0.42
  max:                19.51
  95th percentile:    0.77
  sum:               29021.96

Threads fairness:
  events (avg/Stddev): 69868.0000/0.00
  execution time (avg/stddev): 29.0220/0.00
```

Scenario 2
We are testing this for 3G files

Below are the test case result

Test case 1

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 24MiB each
3GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          507.37
  writes/s:         338.24
  fsyncs/s:        1083.81

Throughput:
  read, MiB/s:      7.93
  written, MiB/s:   5.29

General statistics:
  total time:       30.0333s
  total number of events: 57827

Latency (ms):
  min:                 0.14
  avg:                 0.50
  max:                55.51
  95th percentile:    1.01
  sum:               29123.37

Threads fairness:
  events (avg/stddev): 57827.0000/0.00
  execution time (avg/stddev): 29.1234/0.00
```

Test Case 2:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 24MiB each
3GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          411.43
  writes/s:         274.29
  fsyncs/s:        880.82

Throughput:
  read, MiB/s:      6.43
  written, MiB/s:   4.29

General statistics:
  total time:       30.0385s
  total number of events: 46933

Latency (ms):
  min:                 0.14
  avg:                 0.62
  max:                54.60
  95th percentile:    1.12
  sum:               29277.15

Threads fairness:
  events (avg/stddev): 46933.0000/0.00
  execution time (avg/stddev): 29.2772/0.00
```

Test case 3:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 24MiB each
3GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:           532.81
  writes/s:          355.20
  fsyncs/s:          1136.87

Throughput:
  read, MiB/s:       8.33
  written, MiB/s:    5.55

General statistics:
  total time:        30.0578s
  total number of events: 60743

Latency (ms):
  min:                0.14
  avg:                0.48
  max:                54.46
  95th percentile:   0.86
  sum:               29169.57

Threads fairness:
  events (avg/stddev): 60743.0000/0.00
  execution time (avg/stddev): 29.1696/0.00
```



Test case 4:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 24MiB each
3GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          506.89
  writes/s:         337.95
  fsyncs/s:        1081.66

Throughput:
  read, MiB/s:      7.92
  written, MiB/s:   5.28

General statistics:
  total time:       30.0512s
  total number of events: 57778

Latency (ms):
  min:              0.14
  avg:              0.51
  max:             52.50
  95th percentile: 0.92
  sum:            29192.59

Threads fairness:
  events (avg/stddev): 57778.0000/0.00
  execution time (avg/stddev): 29.1926/0.00
```

Test case 5:

```
QEMU - Press Ctrl-Alt to exit mouse grab
WARNING: --max-time is deprecated, use --time instead
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

Extra file open flags: directio
128 files, 24MiB each
3GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          472.80
  writes/s:         315.20
  fsyncs/s:        1011.04

Throughput:
  read, MiB/s:      7.39
  written, MiB/s:   4.93

General statistics:
  total time:       30.0721s
  total number of events: 53980

Latency (ms):
  min:              0.14
  avg:              0.54
  max:             56.26
  95th percentile: 0.97
  sum:            29197.44

Threads fairness:
  events (avg/stddev): 53980.0000/0.00
  execution time (avg/stddev): 29.1974/0.00
```

Scenario 3

In this fileio script we test for file with size 4G

Below are the test cases result

Test case 1:

```
Threads started!  
[10872.014483] aufs aufs_fill_super:918:mount[63403]: no arg  
File operations:  
    reads/s:          154.69  
    writes/s:         103.13  
    fsyncs/s:        390.57  
Throughput:  
    read, MiB/s:      2.42  
    written, MiB/s:   1.61  
General statistics:  
    total time:       30.2155s  
    total number of events: 17673  
Latency (ms):  
    min:              0.21  
    avg:              1.65  
    max:             864.13  
    95th percentile: 5.00  
    sum:            29158.33  
Threads fairness:  
    events (avg/stddev): 17673.0000/0.00  
    execution time (avg/stddev): 29.1583/0.00
```

Test case 2:

```
Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

[11268.460682] overlayfs: missing 'lowerdir'

File operations:
  reads/s:           194.84
  writes/s:          129.89
  fsyncs/s:          417.77

Throughput:
  read, MiB/s:      3.04
  written, MiB/s:   2.03

General statistics:
  total time:        30.1473s
  total number of events: 22280

Latency (ms):
  min:               0.21
  avg:               1.31
  max:               112.92
  95th percentile:   4.18
  sum:              29120.47

Threads fairness:
  events (avg/stddev): 22280.0000/0.00
  execution time (avg/stddev): 29.1205/0.00
```

Test case 3:

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

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

[11669.453072] aufs aufs_fill_super:918:mount[65309]: no arg
[11674.522585] overlayfs: missing 'lowerdir'

File operations:
  reads/s:           127.84
  writes/s:          85.23
  fsyncs/s:          274.63

Throughput:
  read, MiB/s:      2.00
  written, MiB/s:   1.33

General statistics:
  total time:        30.2547s
  total number of events: 14647

Latency (ms):
  min:                0.25
  avg:                1.99
  max:               920.23
  95th percentile:    6.32
  sum:              29152.25

Threads fairness:
  events (avg/stddev): 14647.0000/0.00
  execution time (avg/stddev): 29.1522/0.00
```

Test case 4:

```
Threads started!  
[11920.737228] aufs aufs_fill_super:918:mount[66426]: no arg  
[11921.687210] overlayfs: missing 'lowerdir'  
[11935.315617] aufs aufs_fill_super:918:mount[66481]: no arg  
[11936.247059] overlayfs: missing 'lowerdir'  
  
File operations:  
    reads/s:                350.80  
    writes/s:               233.87  
    fsyncs/s:               751.66  
  
Throughput:  
    read, MiB/s:            5.48  
    written, MiB/s:          3.65  
  
General statistics:  
    total time:              30.0851s  
    total number of events:   40099  
  
Latency (ms):  
    min:                      0.15  
    avg:                      0.73  
    max:                      56.12  
    95th percentile:           2.57  
    sum:                     29277.14  
  
Threads fairness:  
    events (avg/stddev):     40099.0000/0.00  
    execution time (avg/stddev): 29.2771/0.00  
[11949.173326] aufs aufs_fill_super:918:mount[66538]: no arg
```

Test case 5:

```
Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

[12234.788534] aufs aufs_fill_super:918:mount[67588]: no arg
[12236.043761] overlayfs: missing 'lowerdir'

File operations:
  reads/s:                241.04
  writes/s:               160.68
  fsyncs/s:                518.32

Throughput:
  read, MiB/s:            3.77
  written, MiB/s:          2.51

General statistics:
  total time:              30.1121s
  total number of events:  27591

Latency (ms):
  min:                      0.15
  avg:                      1.06
  max:                      23.17
  95th percentile:          3.75
  sum:                     29239.62

Threads fairness:
  events (avg/stddev):    27591.0000/0.00
  execution time (avg/stddev): 29.2396/0.00
```

Docker installation

Docker installation was very easy. I just went on <https://docs.docker.com/desktop/install/windows-install/> to install docker desktop for windows

To run the ubuntu we need to download the ubuntu image from docker hub. The other way is to execute the command `docker run ubuntu` and this will download the latest image of ubuntu.

Then we can run the ubuntu in interactive mode by using `docker run -it ubuntu` and this will start the ubuntu.

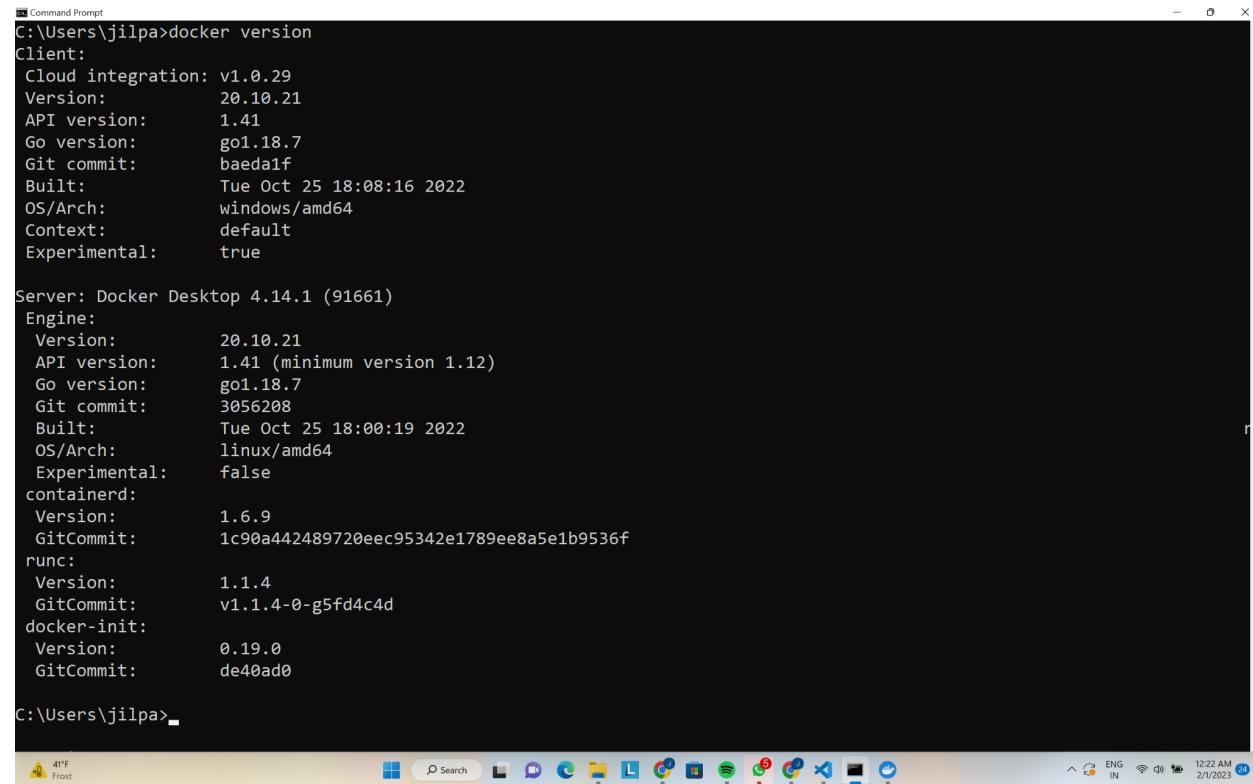
We can then install sysbench

```
$ apt update
```

```
$ apt install sysbench
```

Then install nano to write shell script. Use command `apt install nano`

Docker version

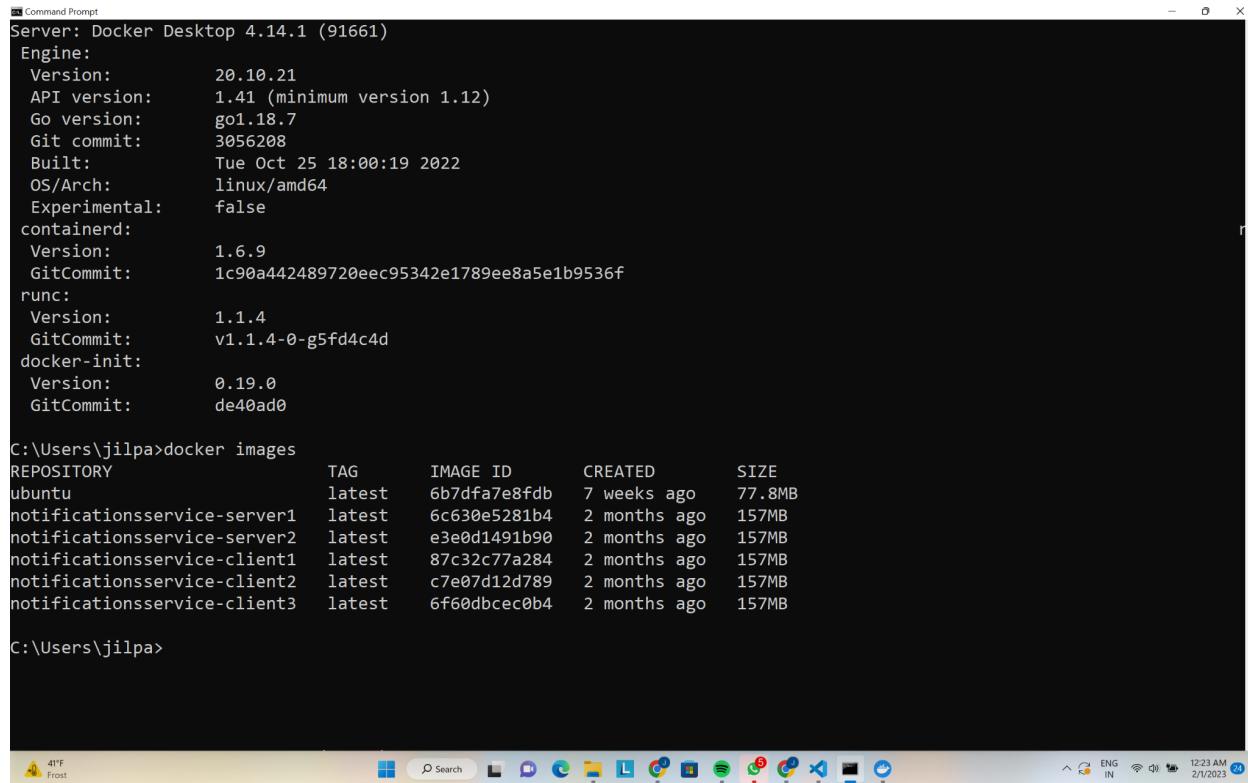


```
C:\Users\jilpa>docker version
Client:
  Cloud integration: v1.0.29
  Version:          20.10.21
  API version:      1.41
  Go version:       go1.18.7
  Git commit:       baeda1f
  Built:            Tue Oct 25 18:08:16 2022
  OS/Arch:          windows/amd64
  Context:          default
  Experimental:    true

Server: Docker Desktop 4.14.1 (91661)
Engine:
  Version:          20.10.21
  API version:      1.41 (minimum version 1.12)
  Go version:       go1.18.7
  Git commit:       3056208
  Built:            Tue Oct 25 18:00:19 2022
  OS/Arch:          linux/amd64
  Experimental:    false
containerd:
  Version:          1.6.9
  GitCommit:        1c90a442489720eec95342e1789ee8a5e1b9536f
runc:
  Version:          1.1.4
  GitCommit:        v1.1.4-0-g5fd4c4d
docker-init:
  Version:          0.19.0
  GitCommit:        de40ad0

C:\Users\jilpa>
```

Docker images



```
Command Prompt
Server: Docker Desktop 4.14.1 (91661)
Engine:
  Version:      20.10.21
  API version:  1.41 (minimum version 1.12)
  Go version:   go1.18.7
  Git commit:   3056208
  Built:        Tue Oct 25 18:00:19 2022
  OS/Arch:      linux/amd64
  Experimental: false
containerd:
  Version:      1.6.9
  GitCommit:    1c90a442489720eec95342e1789ee8a5e1b9536f
runc:
  Version:      1.1.4
  GitCommit:    v1.1.4-0-g5fd4c4d
docker-init:
  Version:      0.19.0
  GitCommit:    de40ad0

C:\Users\jilpa>docker images
REPOSITORY          TAG      IMAGE ID      CREATED       SIZE
ubuntu              latest   6b7dfa7e8fdb  7 weeks ago  77.8MB
notificationsservice-server1  latest   6c630e5281b4  2 months ago  157MB
notificationsservice-server2  latest   e3e0d1491b90  2 months ago  157MB
notificationsservice-client1   latest   87c32c77a284  2 months ago  157MB
notificationsservice-client2   latest   c7e07d12d789  2 months ago  157MB
notificationsservice-client3   latest   6f60dbcec0b4  2 months ago  157MB

C:\Users\jilpa>
```

Experiments results for Docker

CPU Performance

Scenario 1

In scenario 1 we have set the `test-cpu-prime` value to 10000. This means the CPU performance will be tested until the processor verifies the prime number till 10000.

Below are the experimental results

Test case 1

```
root@f80763598d75:/  
(Reading database ... 4529 files and directories currently installed.)  
Preparing to unpack .../archives/nano_6.2-1_amd64.deb ...  
Unpacking nano (6.2-1) ...  
Setting up nano (6.2-1) ...  
update-alternatives: using /bin/nano to provide /usr/bin/editor (editor) in auto mode  
update-alternatives: warning: skip creation of /usr/share/man/man1/editor.1.gz because associated file /usr/share/man/man1/nano.1.gz (of link group editor) doesn't exist  
update-alternatives: using /bin/nano to provide /usr/bin/pico (pico) in auto mode  
update-alternatives: warning: skip creation of /usr/share/man/man1/pico.1.gz because associated file /usr/share/man/man1/nano.1.gz (of link group pico) doesn't exist  
root@f80763598d75:/# nano cpu_test_1.sh  
-----  
QEMU CPU Test  
-----  
Test Case: 1  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 3848.67  
General statistics:  
    total time:          10.00003s  
    total number of events: 38493  
Latency (ms):  
    min:                 0.25  
    avg:                 0.26  
    max:                 0.93  
    95th percentile:    0.28  
    sum:                9992.32  
Threads fairness:  
    events (avg/stddev): 38493.0000/0.00  
    execution time (avg/stddev): 9.9923/0.00  
Test Case: 2  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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!
```



Test case 2

```
root@f80763598d75:/  
total number of events: 38493  
Latency (ms):  
    min: 0.25  
    avg: 0.26  
    max: 0.93  
    95th percentile: 0.28  
    sum: 9992.32  
Threads fairness:  
    events (avg/stddev): 38493.0000/0.00  
    execution time (avg/stddev): 9.9925/0.00  
Test Case: 2  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 3898.11  
General statistics:  
    total time: 10.0002s  
    total number of events: 38088  
Latency (ms):  
    min: 0.25  
    avg: 0.26  
    max: 0.93  
    95th percentile: 0.29  
    sum: 9991.60  
Threads fairness:  
    events (avg/stddev): 38088.0000/0.00  
    execution time (avg/stddev): 9.9916/0.00  
Test Case: 3  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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!
```



Test case 3

```
root@f80763598d75:/  
total number of events: 38988  
  
Latency (ms):  
    min: 0.25  
    avg: 0.26  
    max: 0.92  
    95th percentile: 0.29  
    sum: 9991.60  
  
Threads fairness:  
events (avg/stddev): 38888.0000/0.00  
execution time (avg/stddev): 9.9916/0.00  
  
Test Case: 3  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 3813.27  
  
General statistics:  
total time: 10.0003s  
total number of events: 38143  
  
Latency (ms):  
    min: 0.25  
    avg: 0.26  
    max: 0.90  
    95th percentile: 0.28  
    sum: 9992.22  
  
Threads fairness:  
events (avg/stddev): 38143.0000/0.00  
execution time (avg/stddev): 9.9922/0.00  
  
Test Case: 4  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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!
```

Test Case 4

```
root@f80763598d75:/  
total number of events: 38143  
  
Latency (ms):  
min: 0.25  
avg: 0.26  
max: 0.90  
95th percentile: 0.28  
sum: 9992.22  
  
Threads fairness:  
events (avg/stddev): 38143.0000/0.00  
execution time (avg/stddev): 9.9922/0.00  
  
Test Case: 4  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 3813.90  
  
General statistics:  
total time: 10.0003s  
total number of events: 38145  
  
Latency (ms):  
min: 0.25  
avg: 0.26  
max: 0.92  
95th percentile: 0.29  
sum: 9992.38  
  
Threads fairness:  
events (avg/stddev): 38145.0000/0.00  
execution time (avg/stddev): 9.9924/0.00  
  
Test Case: 5  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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!
```



Test case 5

```
root@f80763598d75:/  
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: 3813.90  
General statistics:  
    total time:          10.00003s  
    total number of events: 38145  
Latency (ms):  
    min:                  0.25  
    avg:                  0.26  
    max:                  0.92  
    95th percentile:     0.29  
    sum:                 9992.38  
Threads fairness:  
    events (avg/stddev): 38145.0000/0.00  
    execution time (avg/stddev): 9.9924/0.00  
Test Case: 5  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 3828.15  
General statistics:  
    total time:          10.00002s  
    total number of events: 38287  
Latency (ms):  
    min:                  0.25  
    avg:                  0.26  
    max:                  0.98  
    95th percentile:     0.28  
    sum:                 9992.40  
Threads fairness:  
    events (avg/stddev): 38287.0000/0.00  
    execution time (avg/stddev): 9.9924/0.00  
root@f80763598d75:/#
```



Scenario 2

For scenario 2 I changed -cpu-max-prime = 30000 to see what is the performance of cpu when the load increases.

Test case 1:

```

root@f80763598d75: /
    avg:          0.26
    max:          0.90
    95th percentile: 0.28
    sum:         9992.40

Threads fairness:
events (avg/stddev): 38287.0000/0.00
execution time (avg/stddev): 9.9924/0.00

root@f80763598d75:/# nano cpu_test_2.sh
root@f80763598d75:/# sh cpu_test_2.sh
QEMU CPU TEST
Running
Test Case: 1
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000

Initializing worker threads...

Threads started!

CPU speed:
events per second: 837.71

General statistics:
total time:          10.0106s
total number of events: 8388

Latency (ms):
min:          1.14
avg:          1.19
max:          3.20
95th percentile: 1.32
sum:         9995.50

Threads fairness:
events (avg/stddev): 8388.0000/0.00
execution time (avg/stddev): 9.9955/0.00

Test Case: 2
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000

Initializing worker threads...

Threads started!

```



Test case 2:

```
root@f80763598d75:/  
total number of events: 8388  
  
Latency (ms):  
min: 1.14  
avg: 1.19  
max: 3.20  
95th percentile: 1.32  
sum: 9995.50  
  
Threads fairness:  
events (avg/stddev): 8388.0000/0.00  
execution time (avg/stddev): 9.9955/0.00  
  
Test Case: 2  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 30000  
  
Initializing worker threads...  
  
Threads started!  
  
CPU speed:  
events per second: 828.00  
  
General statistics:  
total time: 10.0011s  
total number of events: 8283  
  
Latency (ms):  
min: 1.14  
avg: 1.21  
max: 3.13  
95th percentile: 1.42  
sum: 9995.13  
  
Threads fairness:  
events (avg/stddev): 8283.0000/0.00  
execution time (avg/stddev): 9.9951/0.00  
  
Test Case: 3  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 30000  
  
Initializing worker threads...  
Threads started!
```



Test case 3:

```

root@f80763598d75:/  

total number of events: 8283  

Latency (ms):  

  min: 1.14  

  avg: 1.21  

  max: 3.13  

  95th percentile: 1.42  

  sum: 9995.13  

Threads fairness:  

  events (avg/stddev): 8283.0000/0.00  

  execution time (avg/stddev): 9.9951/0.00  

Test Case: 3  

WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  

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: 30000  

Initializing worker threads...  

Threads started!  

CPU speed:  

  events per second: 833.25  

General statistics:  

  total time: 10.00011s  

  total number of events: 8335  

Latency (ms):  

  min: 1.14  

  avg: 1.28  

  max: 3.07  

  95th percentile: 1.39  

  sum: 9995.20  

Threads fairness:  

  events (avg/stddev): 8335.0000/0.00  

  execution time (avg/stddev): 9.9952/0.00  

Test Case: 4  

WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  

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: 30000  

Initializing worker threads...  

Threads started!

```



Test case 4:

```

c:\ root@f80763598d75:/
total number of events: 8335

Latency (ms):
    min: 1.14
    avg: 1.20
    max: 3.07
    95th percentile: 1.39
    sum: 9995.20

Threads fairness:
events (avg/stddev): 8335.0000/0.00
execution time (avg/stddev): 9.9952/0.00

Test Case: 4
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...

Threads started!

CPU speed:
events per second: 826.61

General statistics:
total time: 10.0015s
total number of events: 8269

Latency (ms):
    min: 1.14
    avg: 1.21
    max: 3.57
    95th percentile: 1.47
    sum: 9994.27

Threads fairness:
events (avg/stddev): 8269.0000/0.00
execution time (avg/stddev): 9.9943/0.00

Test Case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...

Threads started!

```



Test case 5:

```

root@f80763598d75:/#
Number of threads: 1
Initializing random number generator from current time

Prime numbers limit: 30000
Initializing worker threads...
Threads started!
CPU speed:
  events per second: 826.61
General statistics:
  total time:          10.0015s
  total number of events: 8269
Latency (ms):
  min:                 1.14
  avg:                 1.21
  max:                 3.57
  95th percentile:    1.47
  sum:                9994.27
Threads fairness:
  events (avg/stddev): 8269.0000/0.00
  execution time (avg/stddev): 9.9943/0.00
Test Case: 5
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 30000
Initializing worker threads...
Threads started!
CPU speed:
  events per second: 815.54
General statistics:
  total time:          10.0008s
  total number of events: 8158
Latency (ms):
  min:                 1.14
  avg:                 1.23
  max:                 3.39
  95th percentile:    1.47
  sum:                9994.89
Threads fairness:
  events (avg/stddev): 8158.0000/0.00
  execution time (avg/stddev): 9.9949/0.00
root@f80763598d75:#
```

Scenario 3:
Here we change the value of cpu-max-prime=50000

Test case 1:

```
root@f80763598d75:/#
events (avg/stddev):      8158.0000/0.00
execution time (avg/stddev):   9.9949/0.00

root@f80763598d75:/# sh cpu_test_3.sh
sh: 0: cannot open cpu_test_3.sh: No such file
root@f80763598d75:/# nano cpu_test_3.sh
root@f80763598d75:/# nano cpu_test_3.sh
root@f80763598d75:/# sh cpu_test_3.sh
QEMU CPU Test
Running
Test Case: 1
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000

Initializing worker threads...

Threads started!

CPU speed:
  events per second: 412.50

General statistics:
  total time:          10.0002s
  total number of events: 4126

Latency (ms):
  min:                  2.30
  avg:                  2.42
  max:                  6.44
  95th percentile:     2.86
  sum:                 9996.25

Threads fairness:
  events (avg/stddev): 4126.0000/0.00
  execution time (avg/stddev):  9.9963/0.00

Test Case: 2
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)

  55°F  Sunny
```

Test case 2:

```
root@f80763598d75:/#
Threads fairness:
  events (avg/stddev):      4126.0000/0.00
  execution time (avg/stddev):   9.9963/0.00

Test Case: 2
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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: 50000

Initializing worker threads...

Threads started!

CPU speed:
  events per second: 411.78

General statistics:
  total time:          10.0098s
  total number of events: 4123

Latency (ms):
  min:                  2.30
  avg:                  2.42
  max:                  5.13
  95th percentile:     2.76
  sum:                 9997.08

Threads fairness:
  events (avg/stddev): 4123.0000/0.00
  execution time (avg/stddev):  9.9971/0.00

Test Case: 3
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
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

  55°F  Sunny
```

Test case 3:

```
root@f80763598475:/  
 execution time (avg/stddev):  9.9971/0.00  
  
Test Case: 3  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 50000  
  
Initializing worker threads...  
  
Threads started!  
  
CPU speed:  
  events per second: 418.47  
  
General statistics:  
  total time:          10.0013s  
  total number of events: 4186  
  
Latency (ms):  
  min:                 2.30  
  avg:                 2.39  
  max:                 3.74  
  95th percentile:    2.66  
  sum:                9997.93  
  
Threads fairness:  
  events (avg/stddev): 4186.0000/0.00  
  execution time (avg/stddev): 9.9979/0.00  
  
Test Case: 4  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 50000
```



Test case 4:

```
root@f80763598d75:/  
      95th percentile:          2.66  
      sum:                  9997.93  
  
Threads fairness:  
  events (avg/stddev):    4186.0000/0.00  
  execution time (avg/stddev):  9.9979/0.00  
  
Test Case: 4  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 50000  
  
Initializing worker threads...  
  
Threads started!  
  
CPU speed:  
  events per second:  408.53  
  
General statistics:  
  total time:           10.0020s  
  total number of events: 4093  
  
Latency (ms):  
  min:                 2.30  
  avg:                 2.44  
  max:                 5.54  
  95th percentile:     3.02  
  sum:                 9997.84  
  
Threads fairness:  
  events (avg/stddev):  4093.0000/0.00  
  execution time (avg/stddev):  9.9978/0.00  
  
Test Case: 5  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
sysbench 1.0.20 (using system LuaJIT 2.1.0-beta3)  
  
Running the test with following options:  
Number of threads: 1  
  
  55°F Sunny  4:35 PM 1/30/2023
```

Test case 5:

```
root@f80763598d75:/  
Test Case: 5  
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.  
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: 50000  
  
Initializing worker threads...  
  
Threads started!  
  
CPU speed:  
  events per second:  412.91  
  
General statistics:  
  total time:           10.0004s  
  total number of events: 4130  
  
Latency (ms):  
  min:                 2.30  
  avg:                 2.42  
  max:                 5.13  
  95th percentile:     2.81  
  sum:                 9996.73  
  
Threads fairness:  
  events (avg/stddev):  4130.0000/0.00  
  execution time (avg/stddev):  9.9967/0.00  
root@f80763598d75:/#  
  
  55°F Sunny  4:35 PM 1/30/2023
```

FileIO testing

Scenario 1

Used file size of 2G

Below are the test case

Test Case 1

```
root@f80763598d75:/ 
Running the test with following options:
Number of threads: 1
Initializing random number generator from current time

Extra file open flags: directio
128 files, 16MiB each
2GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          648.17
  writes/s:         432.11
  fsyncs/s:        1384.62

Throughput:
  read, MiB/s:      10.13
  written, MiB/s:   6.75

General statistics:
  total time:       30.0809s
  total number of events: 74028

Latency (ms):
  min:              0.03
  avg:              0.40
  max:              9.86
  95th percentile:  0.70
  sum:             29959.71

Threads fairness:
  events (avg/stddev):    74028.0000/0.00
  execution time (avg/stddev): 29.9597/0.00

46°F
Clear
Search
L
7:58 PM
1/30/2023
ENG
IN
7:58 PM
1/30/2023
```

Test case 2:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 16MiB each  
2GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          812.30  
    writes/s:         541.53  
    fsyncs/s:        1736.26  
  
Throughput:  
    read, MiB/s:     12.69  
    written, MiB/s:  8.46  
  
General statistics:  
    total time:      30.0615s  
    total number of events: 92769  
  
Latency (ms):  
    min:              0.03  
    avg:              0.32  
    max:              8.30  
    95th percentile: 0.56  
    sum:             29950.71  
  
Threads fairness:  
    events (avg/stddev): 92769.0000/0.00  
    execution time (avg/stddev): 29.9507/0.00  
  
8:00 PM 1/30/2023
```

Test case 3:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 16MiB each  
2GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          810.10  
    writes/s:         540.06  
    fsyncs/s:        1728.29  
  
Throughput:  
    read, MiB/s:     12.66  
    written, MiB/s:  8.44  
  
General statistics:  
    total time:      30.0673s  
    total number of events: 92438  
  
Latency (ms):  
    min:              0.03  
    avg:              0.32  
    max:              8.01  
    95th percentile: 0.55  
    sum:             29946.56  
  
Threads fairness:  
    events (avg/stddev): 92438.0000/0.00  
    execution time (avg/stddev): 29.9466/0.00  
  
8:01 PM 1/30/2023
```

Test case 4:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 16MiB each  
2GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
  reads/s:          649.95  
  writes/s:         433.30  
  fsyncs/s:        1390.59  
  
Throughput:  
  read, MiB/s:      10.16  
  written, MiB/s:   6.77  
  
General statistics:  
  total time:           30.0923s  
  total number of events: 74321  
  
Latency (ms):  
  min:                 0.03  
  avg:                0.40  
  max:                8.89  
  95th percentile:    0.72  
  sum:               29958.02  
  
Threads fairness:  
  events (avg/stddev): 74321.0000/0.00  
  execution time (avg/stddev): 29.9580/0.00
```



Test case 5:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 16MiB each  
2GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
  reads/s:          826.15  
  writes/s:         556.76  
  fsyncs/s:        1765.34  
  
Throughput:  
  read, MiB/s:      12.91  
  written, MiB/s:   8.61  
  
General statistics:  
  total time:       30.0660s  
  total number of events: 94351  
  
Latency (ms):  
  min:              0.03  
  avg:             0.32  
  max:             7.65  
  95th percentile: 0.56  
  sum:            29951.27  
  
Threads fairness:  
  events (avg/stddev):    94351.0000/0.00  
  execution time (avg/stddev): 29.9513/0.00
```



Scenario 2: Used file size of 3G

Below are the test case

Test Case 1

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 24MiB each  
3GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          818.16  
    writes/s:         545.44  
    fsyncs/s:        1748.83  
  
Throughput:  
    read, MiB/s:      12.78  
    written, MiB/s:   8.52  
  
General statistics:  
    total time:       30.0662s  
    total number of events: 93455  
  
Latency (ms):  
    min:              0.04  
    avg:              0.32  
    max:              8.91  
    95th percentile:  0.54  
    sum:             29952.26  
  
Threads fairness:  
    events (avg/stddev): 93455.0000/0.00  
    execution time (avg/stddev): 29.9523/0.00  
  
8:09 PM 1/30/2023
```

Test case 2:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 24MiB each  
3GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          834.16  
    writes/s:         556.10  
    fsyncs/s:        1782.13  
  
Throughput:  
    read, MiB/s:      13.03  
    written, MiB/s:   8.69  
  
General statistics:  
    total time:       30.0650s  
    total number of events: 95254  
  
Latency (ms):  
    min:              0.03  
    avg:              0.31  
    max:              12.12  
    95th percentile:  0.55  
    sum:             29950.09  
  
Threads fairness:  
    events (avg/stddev): 95254.0000/0.00  
    execution time (avg/stddev): 29.9501/0.00  
  
8:09 PM 1/30/2023
```

Test case 3:

```
root@f80763598d75:/  
  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 24MiB each  
3GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          650.20  
    writes/s:        433.47  
    fsyncs/s:       1389.19  
  
Throughput:  
    read, MiB/s:      10.16  
    written, MiB/s:   6.77  
  
General statistics:  
    total time:           30.0816s  
    total number of events: 74263  
  
Latency (ms):  
    min:                 0.03  
    avg:                0.40  
    max:               43.14  
    95th percentile:     0.70  
    sum:              29956.07  
  
Threads fairness:  
    events (avg/stddev): 74263.0000/0.00  
    execution time (avg/stddev): 29.9561/0.00
```


Test case 4:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 24MiB each  
3GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
  reads/s:          628.07  
  writes/s:         418.71  
  fsyncs/s:        1343.57  
  
Throughput:  
  read, MiB/s:      9.81  
  written, MiB/s:   6.54  
  
General statistics:  
  total time:       30.0907s  
  total number of events: 71803  
  
Latency (ms):  
  min:              0.03  
  avg:              0.42  
  max:              16.03  
  95th percentile:  0.73  
  sum:             29955.99  
  
Threads fairness:  
  events (avg/stddev):    71803.0000/0.00  
  execution time (avg/stddev): 29.9560/0.00
```

Test case 5:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 24MiB each  
3GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
  reads/s:          702.01  
  writes/s:         468.01  
  fsyncs/s:        1501.68  
  
Throughput:  
  read, MiB/s:      10.97  
  written, MiB/s:   7.31  
  
General statistics:  
  total time:       30.0835s  
  total number of events: 80250  
  
Latency (ms):  
  min:              0.03  
  avg:              0.37  
  max:              8.90  
  95th percentile:  0.69  
  sum:             29950.89  
  
Threads fairness:  
  events (avg/stddev):    80250.0000/0.00  
  execution time (avg/stddev): 29.9509/0.00
```

Scenario 3:

Used file size of 4G

Below are the test case

Test Case 1

```
root@f8076359bd75:~$ 
Running the test with following options:
Number of threads: 1
Initializing random number generator from current time

Extra file open flags: directio
128 files, 32MiB each
4GiB total file size
Block size 16KiB
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 r/w test
Initializing worker threads...

Threads started!

File operations:
  reads/s:          820.27
  writes/s:         546.85
  fsyncs/s:        1751.47

Throughput:
  read, MiB/s:      12.82
  written, MiB/s:   8.54

General statistics:
  total time:       30.0620s
  total number of events: 93627

Latency (ms):
  min:              0.03
  avg:              0.32
  max:              8.96
  95th percentile:  0.55
  sum:             29945.99

Threads fairness:
  events (avg/stddev): 93627.0000/0.00
  execution time (avg/stddev): 29.9460/0.00

8:18 PM 1/30/2023
```

Test case 2:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 32MiB each  
4GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          610.29  
    writes/s:         406.86  
    fsyncs/s:        1303.06  
  
Throughput:  
    read, MiB/s:      9.54  
    written, MiB/s:   6.36  
  
General statistics:  
    total time:       30.0825s  
    total number of events: 69673  
  
Latency (ms):  
    min:              0.03  
    avg:              0.43  
    max:              28.98  
    95th percentile:  0.74  
    sum:             29953.52  
  
Threads fairness:  
    events (avg/stddev): 69673.0000/0.00  
    execution time (avg/stddev): 29.9535/0.00
```



Test case 3:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 32MiB each  
4GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          632.25  
    writes/s:         421.50  
    fsyncs/s:        1352.68  
  
Throughput:  
    read, MiB/s:      9.88  
    written, MiB/s:   6.59  
  
General statistics:  
    total time:       30.0818s  
    total number of events: 72265  
  
Latency (ms):  
    min:              0.03  
    avg:              0.41  
    max:              9.12  
    95th percentile:  0.73  
    sum:             29955.72  
  
Threads fairness:  
    events (avg/stddev): 72265.0000/0.00  
    execution time (avg/stddev): 29.9557/0.00
```



Test case 4:

```
root@f8076359bd75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 32MiB each  
4GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
  
Threads started!  
  
File operations:  
    reads/s:          814.22  
    writes/s:        542.81  
    fsyncs/s:       1737.03  
  
Throughput:  
    read, MiB/s:      12.72  
    written, MiB/s:   8.48  
  
General statistics:  
    total time:           30.0645s  
    total number of events: 92897  
  
Latency (ms):  
    min:                 0.03  
    avg:                0.32  
    max:                8.65  
    95th percentile:     0.56  
    sum:               29954.49  
  
Threads fairness:  
    events (avg/stddev): 92897.0000/0.00  
    execution time (avg/stddev): 29.9545/0.00
```



Test case 5:

```
root@f80763598d75:/  
Running the test with following options:  
Number of threads: 1  
Initializing random number generator from current time  
  
Extra file open flags: directio  
128 files, 32MiB each  
4GiB total file size  
Block size 16KiB  
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 r/w test  
Initializing worker threads...  
Threads started!  
  
File operations:  
    reads/s:          806.39  
    writes/s:         537.59  
    fsyncs/s:        1720.50  
  
Throughput:  
    read, MiB/s:      12.60  
    written, MiB/s:   8.40  
  
General statistics:  
    total time:       30.0581s  
    total number of events: 91990  
  
Latency (ms):  
    min:              0.03  
    avg:              0.33  
    max:              8.28  
    95th percentile:  0.55  
    sum:             29953.13  
  
Threads fairness:  
    events (avg/stddev): 91990.0000/0.00  
    execution time (avg/stddev): 29.9531/0.00
```



Os Virtualization and System Virtualization performances results and comparison

Ubuntu Virtual Machine on QEMU

Experiment -1 -cpu-max-prime=10000

Test Run	Total Time	CPU Speed	Average Latency
1	10.0028	612.95	1.61
2	10.0017	614.23	1.61
3	10.0018	625.96	1.59
4	10.0027	624.21	1.58
5	10.0021	618.27	1.61
Min	10.0017	612.95	1.58
Max	10.0028	625.96	1.61
Avg	10.00212	619.124	1.60
Standard Deviation	0.00040	5.8180	0.00141

Experiment 2 -cpu-max-prime=30000

Test Run	Total Time	CPU Speed	Average Latency
1	10.0038	148.09	6.73
2	10.0020	148.11	6.70
3	10.0076	147.52	6.76
4	10.0058	146.02	6.8
5	10.0049	148.77	6.7

Min	10.002	146.02	6.7
Max	10.0076	148.77	6.8
Avg	10.00482	147.702	6.738
Standard Deviation	0.002102855202	1.039216051	0.04266145802

Experiment 3 -cpu-max-prime=50000

Test Run	Total Time	CPU Speed	Average Latency
1	10.0098	75.84	13.15
2	10.0020	74.99	13.23
3	10.0012	75.48	13.21
4	10.0123	74.78	13.34
5	10.0122	75.48	13.20
Min	10.0012	74.78	13.15
Max	10.0123	75.84	13.34
Avg	10.0075	75.314	13.226
Standard Deviation	0.005485435261	0.4248293775	0.07021395873

Docker Ubuntu

Experiment -cpu-max-prime = 10000

Test Run	Total Time	CPU Speed	Average Latency
1	10.0003	3848.67	0.26

2	10.0020	3808.11	0.26
3	10.0003	3813.27	0.26
4	10.0003	3813.90	0.26
5	10.0002	3828.15	0.26
Min	10.0002	3808.11	0.26
Max	10.002	3848.67	0.26
Avg	10.00062	3822.42	0.26
Standard Deviation	0.0007726577509	16.45436416	0

Experiment -cpu-max-prime = 30000

Test Run	Total Time	CPU Speed	Average Latency
1	10.0106	837.71	1.19
2	10.0011	828.00	1.21
3	10.0011	833.25	1.20
4	10.0015	826.61	1.21
5	10.0008	815.54	1.23
Min	10.0008	815.54	1.19
Max	10.0106	837.71	1.23
Avg	10.00302	828.222	1.208
Standard Deviation	0.004244643684	8.348411226	0.01483239697

Experiment -cpu-max-prime = 50000

Test Run	Total Time	CPU Speed	Average Latency
1	10.0002	412.50	2.42

2	10.0098	411.78	2.42
3	10.0013	418.47	2.39
4	10.002	408.53	2.44
5	10.0004	412.9	2.42
Min	10.0002	408.53	2.39
Max	10.0098	418.47	2.44
Avg	10.00274	412.836	2.418
Standard Deviation	0.004012231299	3.588722614	0.01788854382

FileIO Performance Experiments

FileIO performance for Ubuntu on QEMU

Experiment 1 - file-size = 2G

Test Run	Read Throughput	Write Throughput	Total Time
1	9.06	6.04	30.0369
2	8.46	5.64	30.0400
3	8.58	5.72	30.0372
4	8.48	5.65	30.080
5	9.57	6.38	30.0773
Min	8.46	5.64	30.0369
Max	9.57	6.38	30.08
Avg	8.83	5.886	30.05428

Standard Deviation	0.4802082881	0.3207491231	0.02229993274
--------------------	--------------	--------------	---------------

Experiment 2 - file-size = 3G

Test Run	Read Throughput	Write Throughput	Total Time
1	7.93	5.29	30.0333
2	6.43	4.29	30.0385
3	8.33	5.55	30.0578
4	7.92	5.20	30.0512
5	7.39	4.93	30.0721
Min	6.43	4.29	30.0333
Max	8.33	5.55	30.0721
Avg	7.6	5.052	30.05058
Standard Deviation	0.7343704787	0.4801249837	0.01549312751

Experiment 3 - file-size = 4G

Test Run	Read Throughput	Write Throughput	Total Time
1	8.93	6.29	30.0543
2	7.31	5.29	30.0495
3	6.71	4.21	30.0378
4	9.92	7.20	30.0952
5	7.81	7.14	30.0621
Min	6.71	4.21	30.0378
Max	9.92	7.2	30.0952

Avg	8.136	6.026	30.05978
Standard Deviation	1.287936334	1.277548434	0.02167249409

FileIO performance for Docker Ubuntu

Experiment 1 - file-size = 2G

Test Run	Read Throughput	Write Throughput	Total Time
1	10.13	6.75	30.0809
2	12.69	8.46	30.0615
3	12.66	8.44	30.0673
4	10.16	6.77	30.0923
5	12.91	8.61	30.0660
Min	10.13	6.75	30.0615
Max	12.91	8.61	30.0923
Avg	11.71	7.806	30.0736
Standard Deviation	1.431939245	0.9571468017	0.01271652468

Experiment 1 - file-size = 3G

Test Run	Read Throughput	Write Throughput	Total Time
1	12.78	8.52	30.0662
2	13.03	8.69	30.0650
3	10.16	6.77	30.0816
4	9.81	6.54	30.0907
5	10.97	7.31	30.0835

Min	9.81	6.54	30.065
Max	13.03	8.69	30.0907
Avg	11.35	7.566	30.0774
Standard Deviation	1.483189132	0.9906210173	0.01130199098

Experiment 1 - file-size = 4G

Test Run	Read Throughput	Write Throughput	Total Time
1	12.82	8.54	30.0620
2	9.54	6.36	30.0825
3	9.88	6.59	30.0818
4	12.72	8.48	30.0645
5	12.60	8.40	30.0581
Min	9.54	6.36	30.0581
Max	12.82	8.54	30.0825
Avg	11.512	7.674	30.06978
Standard Deviation	1.651217732	1.098671926	0.01152289026

Comparison

Comparing results, we can say that in both CPU performance test and FileIO test Docker performs better than QEMU.

Conclusion

As Docker Containers are light in weight, Docker containers should perform better than QEMU Ubuntu virtual machines. From the experiments performed above we observed that Docker executes the instructions faster than the QEMU Ubuntu Virtual Machine which is the ideal case. Also in terms of File IO, Docker performed well which I think because docker container are fast

and light weighted. In most cases Docker outperforms VMs, but there are cases where VMs work faster such as security.