COEN 241 - HW- 1

QEMU (System Virtualization) Setup

As a requirement of the assignment, QEMU has to be installed on which a QEMU image is created to install a VM.

The system configuration for this assignment is as follows:

Downloading the Ubuntu ISO Server Image:

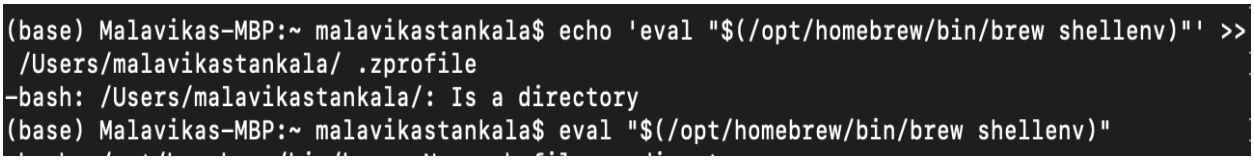
Download the ubuntu iso image from the following link: https://releases.ubuntu.com/focal/ubuntu-20.04.5-live-server-amd64.iso
Then place the iso file in the appropriate path in Ubuntu to create the image for the QEMU virtual machine.

INSTALLING QEMU USING HOMEBREW:

1. Install Homebrew using:

   /bin/bash-c"$(curl-fsSLhttps://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"

2. Add Homebrew to your path using:

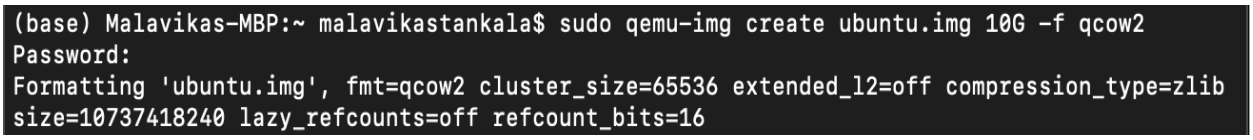


3. To check if Homebrew is installed properly use:
   brew doctor

4. To install QEMU use:
   brew install qemu

Creating a QEMU image:

Create a QEMU image to install the VM by using:



So here, an image under the name ubuntu with 10GB of space is created. Also, -f denotes the file format, which is qcow2 here.

Installing the VM

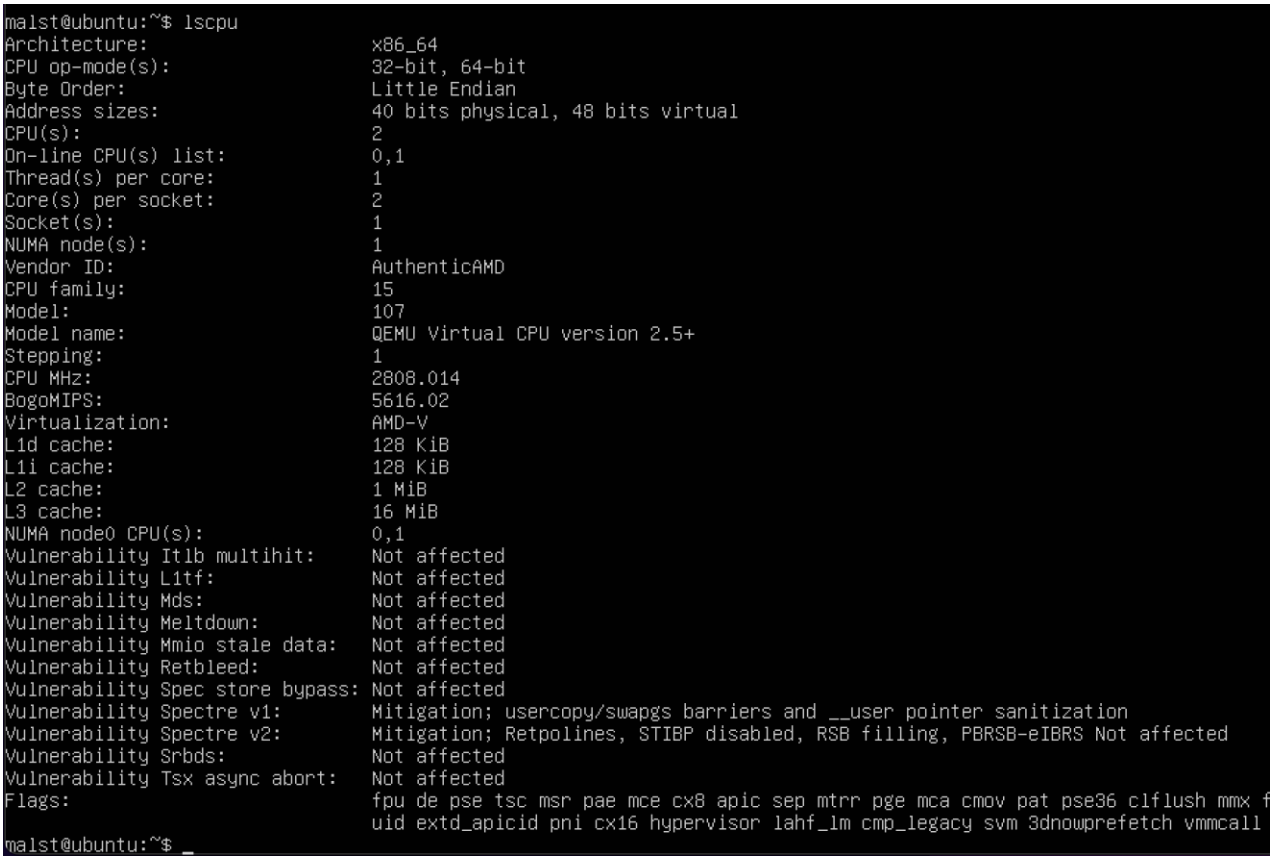
Install the VM using:

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

Once the above command runs successfully, follow the instructions on the screen to install the QEMU Ubuntu VM image in the system.

To run the image, run the above command without the -cdrom option.

Then when the configuration of smp is changed to one, we observe the change in no.of cores per socket modified from 2 to 1.



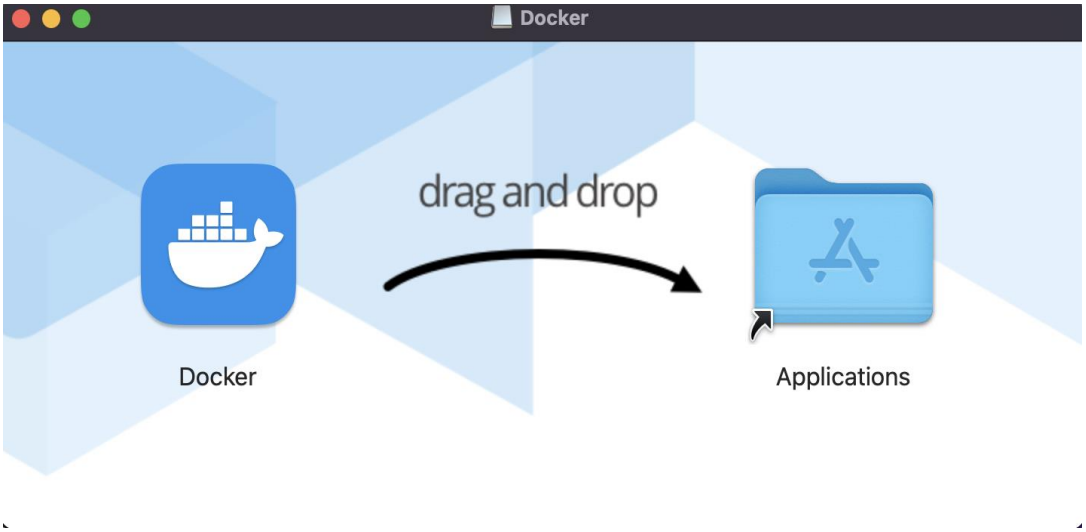
```
malst@ubuntu:~$ lscpu
Architecture:                    x86_64
CPU op-mode(s):                  32-bit, 64-bit
Byte Order:                      Little Endian
Address sizes:                   40 bits physical, 48 bits virtual
CPU(s):                          1
On-line CPU(s) list:             0
Thread(s) per core:              1
Core(s) per socket:              1
Socket(s):                       1
NUMA node(s):                    1
Vendor ID:                       AuthenticAMD
CPU family:                      15
Model:                           107
Model name:                      QEMU Virtual CPU version 2.5+
Stepping:                        1
CPU MHz:                         2807.839
BogoMIPS:                        5615.67
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: Not affected
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
                                  extd_apicid pni cx16 hypervisor lahf_lm svm 3dnowprefetch vmmcall
malst@ubuntu:~$ _
```

Ubuntu VM Configuration

```
malst@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-7.2
           serial: <superuser/root required>
           Mobo: N/A model: N/A serial: N/A BIOS: SeaBIOS v: rel-1.16.1-0-g3208b098f51a-prebuilt.qemu.org date: 04/01/2014
CPU:       Topology: Dual Core model: QEMU Virtual version 2.5+ bits: 64 type: MCP arch: K8 rev.F+ rev: 1 L2 cache: 1024 KiB
           flags: lm nx pae sse sse2 sse3 svm bogomips: 10990
           Speed: 2808 MHz min/max: N/A Core speeds (MHz): 1: 2808 2: 2808
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: 160x50
           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: 4.05 GiB (50.5%) 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: 13m Memory: 1.93 GiB used: 216.4 MiB (10.9%) Init: systemd runlevel: 5 Compilers: gcc: N/A
           Shell: bash v: 5.0.17 inxi: 3.0.38
malst@ubuntu:~$
```

INSTALLING DOCKER

1. Install docker from the following link : https://docs.docker.com/desktop/mac/install/



2. To run the docker engine, start the application from the applications folder.
3. Run docker run hello-world

```
(base) Malavikas-MBP:~ malavikastankala$ docker run hello-world
Unable to find image 'hello-world:latest' locally
latest: Pulling from library/hello-world
2db29710123e: Pull complete
Digest: sha256:aa0cc8055b82dc2509bed2e19b275c8f463506616377219d9642221ab53cf9fe
Status: Downloaded newer image for hello-world:latest

Hello from Docker!
This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
    (amd64)
 3. The Docker daemon created a new container from that image which runs the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which sent it
    to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker ID:
 https://hub.docker.com/

For more examples and ideas, visit:
 https://docs.docker.com/get-started/

(base) Malavikas-MBP:~ malavikastankala$
```

4. Check docker version

```
(base) Malavikas-MBP:~ malavikastankala$ docker version
Client:
 Cloud integration: v1.0.29
 Version:           20.10.22
 API version:       1.41
 Go version:        go1.18.9
 Git commit:        3a2c30b
 Built:             Thu Dec 15 22:28:41 2022
 OS/Arch:           darwin/amd64
 Context:           default
 Experimental:      true

Server: Docker Desktop 4.16.2 (95914)
 Engine:
  Version:          20.10.22
  API version:      1.41 (minimum version 1.12)
  Go version:       go1.18.9
  Git commit:       42c8b31
  Built:            Thu Dec 15 22:26:14 2022
  OS/Arch:          linux/amd64
  Experimental:     false
 containerd:
  Version:          1.6.14
  GitCommit:        9ba4b250366a5ddde94bb7c9d1def331423aa323
 runc:
  Version:          1.1.4
  GitCommit:        v1.1.4-0-g5fd4c4d
 docker-init:
  Version:          0.19.0
  GitCommit:        de40ad0
(base) Malavikas-MBP:~ malavikastankala$
```

5. Open terminal and execute the following commands:
    a. docker run -it –name ubuntu1 ubuntu:focal
    b. docker start ubuntu1
    c. docker exec -it ubuntu1 bash
    d. apt-get update
    e. apt-get -y install sysbench

EXPERIMENTS

QEMU CPU Testing

Scenario 1:

The CPU is tested using the cpu-max-prime where the max prime number is found under the given limit. Command used: CPU Time - sysbench --test=cpu --cpu-max-prime=10000 run

Case 1:

```
Test Case: 1
WARNING: the --test option is deprecated. You can pass a scr
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:   277.65

General statistics:
    total time:                          10.0029s
    total number of events:              2779

Latency (ms):
         min:                                    3.46
         avg:                                    3.58
         max:                                    5.26
         95th percentile:                        3.75
         sum:                                 9959.37

Threads fairness:
    events (avg/stddev):           2779.0000/0.00
    execution time (avg/stddev):   9.9594/0.00

Test Case: 2
```

Case 2:

```
Test Case: 2
WARNING: the --test option is deprecated. You can pass a script nam
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:   275.23

General statistics:
    total time:                          10.0036s
    total number of events:              2755

Latency (ms):
         min:                                    3.46
         avg:                                    3.61
         max:                                   15.73
         95th percentile:                        3.82
         sum:                                 9953.73

Threads fairness:
    events (avg/stddev):           2755.0000/0.00
    execution time (avg/stddev):   9.9537/0.00
```

Case 3:

```
Test Case: 3
WARNING: the --test option is deprecated. You can pass a scrip
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:   273.41

General statistics:
    total time:                          10.0011s
    total number of events:              2736

Latency (ms):
         min:                                    3.46
         avg:                                    3.64
         max:                                    6.51
         95th percentile:                        3.89
         sum:                                 9945.69

Threads fairness:
    events (avg/stddev):           2736.0000/0.00
    execution time (avg/stddev):   9.9457/0.00
```

Case 4:

```
Test Case: 4
WARNING: the --test option is deprecated. You can pass a scrip
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:   265.97

General statistics:
    total time:                          10.0023s
    total number of events:              2662

Latency (ms):
         min:                                    3.46
         avg:                                    3.73
         max:                                    5.87
         95th percentile:                        4.25
         sum:                                 9937.86

Threads fairness:
    events (avg/stddev):           2662.0000/0.00
    execution time (avg/stddev):   9.9379/0.00
```

Case 5:

```
Test Case: 5
WARNING: the --test option is deprecated. You can pass a scri
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:   278.58

General statistics:
    total time:                          10.0016s
    total number of events:              2788

Latency (ms):
         min:                                    3.46
         avg:                                    3.57
         max:                                    6.70
         95th percentile:                        3.68
         sum:                                 9958.09

Threads fairness:
    events (avg/stddev):           2788.0000/0.00
    execution time (avg/stddev):   9.9581/0.00

malst@ubuntu:~$ sh cpu_t1.sh
```

Scenario 2

The CPU is tested using the cpu-max-prime where the max prime number is found under the given limit. Command used: CPU Time - sysbench --test=cpu --cpu-max-prime=30000 run

Case 1:

```
Test Case: 1
WARNING: the --test option is deprecated. You can pass a script nam
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:    58.26

General statistics:
    total time:                          10.0137s
    total number of events:              584

Latency (ms):
         min:                                    15.45
         avg:                                    17.08
         max:                                    66.40
         95th percentile:                        24.38
         sum:                                  9974.39

Threads fairness:
    events (avg/stddev):           584.0000/0.00
    execution time (avg/stddev):   9.9744/0.00

Test Case: 2
```

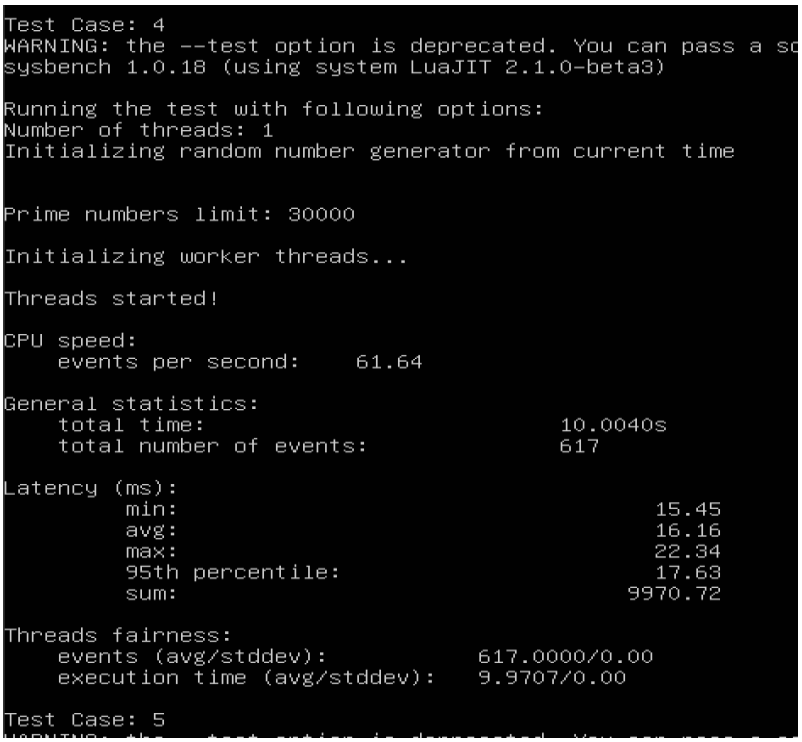
Case 2:

```
Test Case: 2
WARNING: the --test option is deprecated. You can pass a script
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:    62.49

General statistics:
    total time:                          10.0116s
    total number of events:              626

Latency (ms):
         min:                                    15.45
         avg:                                    15.94
         max:                                    39.05
         95th percentile:                        16.41
         sum:                                  9981.48

Threads fairness:
    events (avg/stddev):           626.0000/0.00
    execution time (avg/stddev):   9.9815/0.00
```

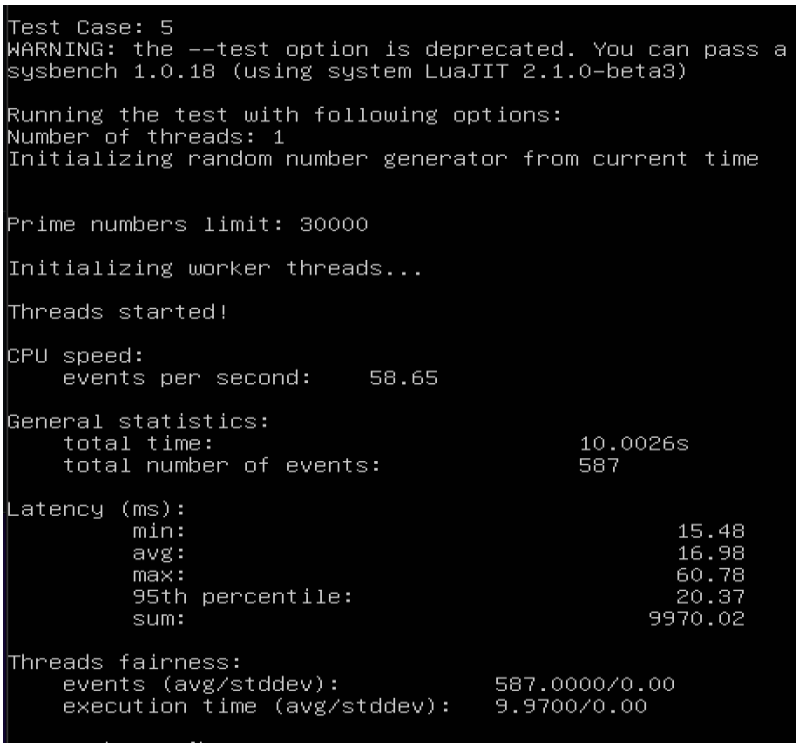
Case 3:

```
Test Case: 3
WARNING: the --test option is deprecated. You can pass a
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:    60.40

General statistics:
    total time:                          10.0098s
    total number of events:              605

Latency (ms):
         min:                                    15.45
         avg:                                    16.49
         max:                                    55.07
         95th percentile:                        18.28
         sum:                                  9976.93

Threads fairness:
    events (avg/stddev):           605.0000/0.00
    execution time (avg/stddev):   9.9769/0.00

Test Case: 4
```

Case 4:


Test Case: 4
WARNING: the --test option is deprecated. You can pass a sc
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: 61.64
General statistics:
total time: 10.0040s
total number of events: 617
Latency (ms):
min: 15.45
avg: 16.16
max: 22.34
95th percentile: 17.63
sum: 9970.72
Threads fairness:
events (avg/stddev): 617.0000/0.00
execution time (avg/stddev): 9.9707/0.00
Test Case: 5

Case 5:


Test Case: 5
WARNING: the --test option is deprecated. You can pass a
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: 58.65
General statistics:
total time: 10.0026s
total number of events: 587
Latency (ms):
min: 15.48
avg: 16.98
max: 60.78
95th percentile: 20.37
sum: 9970.02
Threads fairness:
events (avg/stddev): 587.0000/0.00
execution time (avg/stddev): 9.9700/0.00

Scenario 3

The CPU is tested using the cpu-max-prime where the max prime number is found under the given limit. Command used: CPU Time - sysbench --test=cpu --cpu-max-prime=50000 run

Case 1:

```
Test Case: 1
WARNING: the --test option is deprecated. You can pass a
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:    31.42

General statistics:
    total time:                          10.0199s
    total number of events:              315

Latency (ms):
         min:                                    31.04
         avg:                                    31.67
         max:                                    39.05
         95th percentile:                        32.53
         sum:                                  9976.32

Threads fairness:
    events (avg/stddev):           315.0000/0.00
    execution time (avg/stddev):   9.9763/0.00

Test Case: 2
```

Case 2:

```
Test Case: 2
WARNING: the --test option is deprecated. You can pass a
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:    30.96

General statistics:
    total time:                          10.0282s
    total number of events:              311

Latency (ms):
         min:                                    31.09
         avg:                                    32.16
         max:                                    60.66
         95th percentile:                        33.12
         sum:                                 10002.39

Threads fairness:
    events (avg/stddev):           311.0000/0.00
    execution time (avg/stddev):   10.0024/0.00

Test Case: 3
```

Case 3:

```
Test Case: 3
WARNING: the --test option is deprecated. You can pass a
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:    30.59

General statistics:
    total time:                          10.0288s
    total number of events:              307

Latency (ms):
         min:                                    31.09
         avg:                                    32.58
         max:                                    43.69
         95th percentile:                        35.59
         sum:                                 10002.47

Threads fairness:
    events (avg/stddev):           307.0000/0.00
    execution time (avg/stddev):   10.0025/0.00
```

Case 4:

```
Test Case: 4
WARNING: the --test option is deprecated. You can pass a
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:    30.74

General statistics:
    total time:                          10.0148s
    total number of events:              308

Latency (ms):
         min:                                    31.14
         avg:                                    32.44
         max:                                    37.79
         95th percentile:                        34.95
         sum:                                  9990.32

Threads fairness:
    events (avg/stddev):           308.0000/0.00
    execution time (avg/stddev):   9.9903/0.00

Test Case: 5
```

Case 5:

```
Test Case: 5
WARNING: the --test option is deprecated. You can pass a
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:    30.97

General statistics:
    total time:                          10.0027s
    total number of events:              310

Latency (ms):
         min:                                    31.01
         avg:                                    32.19
         max:                                    41.60
         95th percentile:                        34.33
         sum:                                  9979.06

Threads fairness:
    events (avg/stddev):           310.0000/0.00
    execution time (avg/stddev):   9.9791/0.00
```

QEMU FILE I/O TESTING

Scenario 1

Command used:

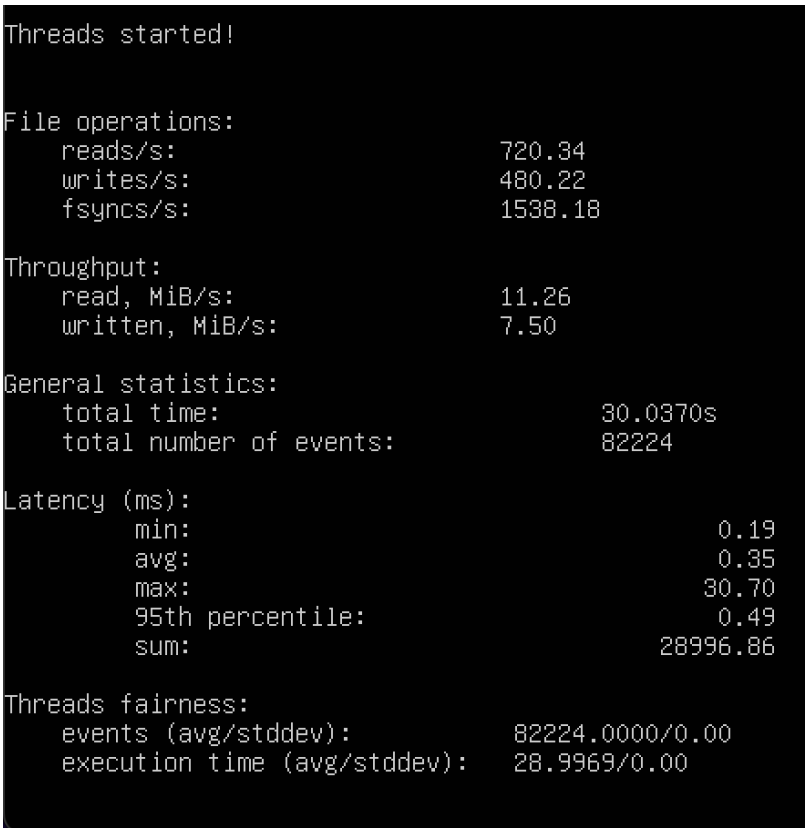
sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=30 --max-requests=0 --file- extra-flags=direct prepare

sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=30 --max-requests=0 -- file-extra-flags=direct run

sleep 60

sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=30 --max-requests=0 -- file-extra-flags=direct cleanup

Case 1:



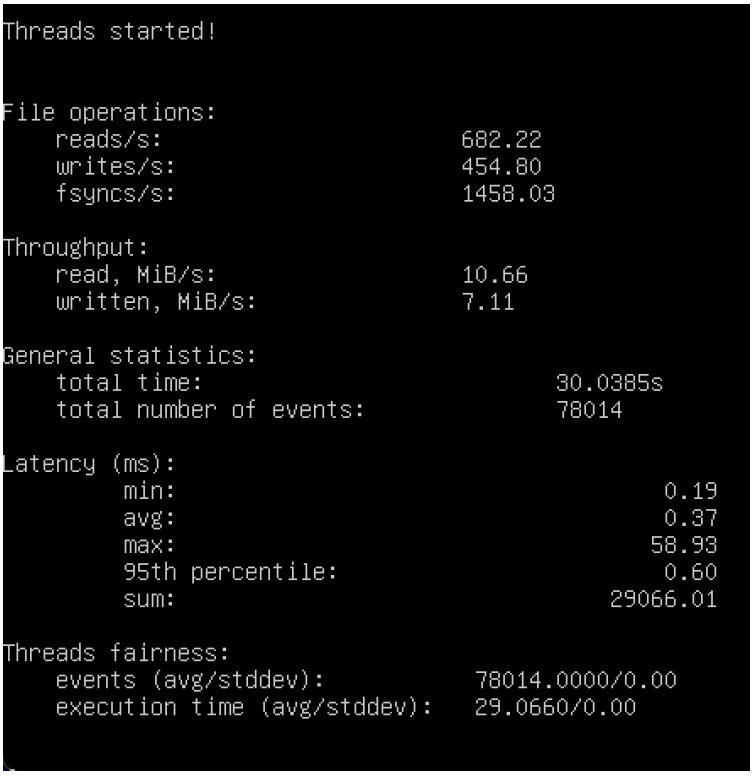
Case 2:

```
Threads started!


File operations:
    reads/s:                      648.46
    writes/s:                     432.30
    fsyncs/s:                     1386.78

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

General statistics:
    total time:                          30.0368s
    total number of events:              74120

Latency (ms):
         min:                                    0.20
         avg:                                    0.39
         max:                                   51.13
         95th percentile:                        0.63
         sum:                                28963.03

Threads fairness:
    events (avg/stddev):           74120.0000/0.00
    execution time (avg/stddev):   28.9630/0.00
```

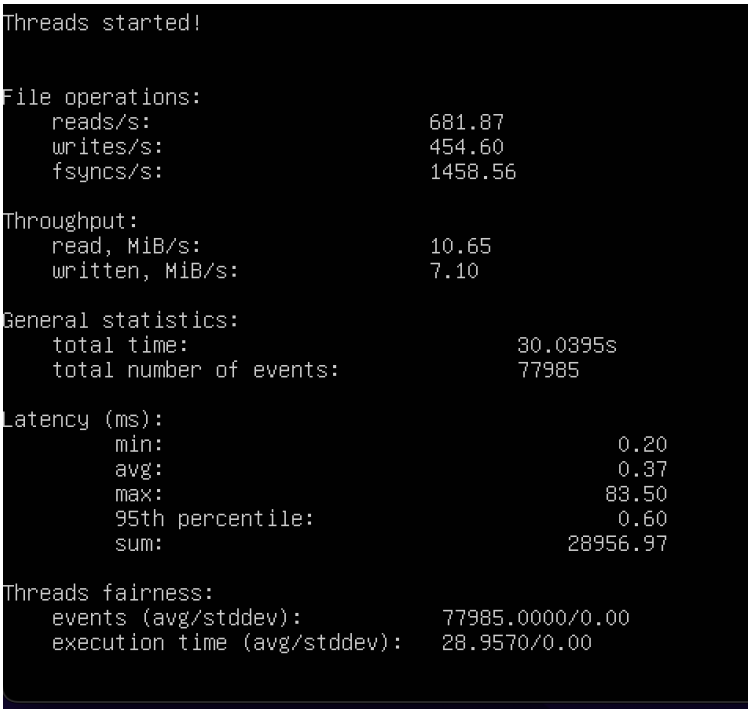
Case 3:

```
Threads started!


File operations:
    reads/s:                      674.73
    writes/s:                     449.83
    fsyncs/s:                     1441.90

Throughput:
    read, MiB/s:                  10.54
    written, MiB/s:               7.03

General statistics:
    total time:                          30.0392s
    total number of events:              77106

Latency (ms):
         min:                                    0.19
         avg:                                    0.38
         max:                                   39.93
         95th percentile:                        0.61
         sum:                                29020.72

Threads fairness:
    events (avg/stddev):           77106.0000/0.00
    execution time (avg/stddev):   29.0207/0.00
```

Case 4:

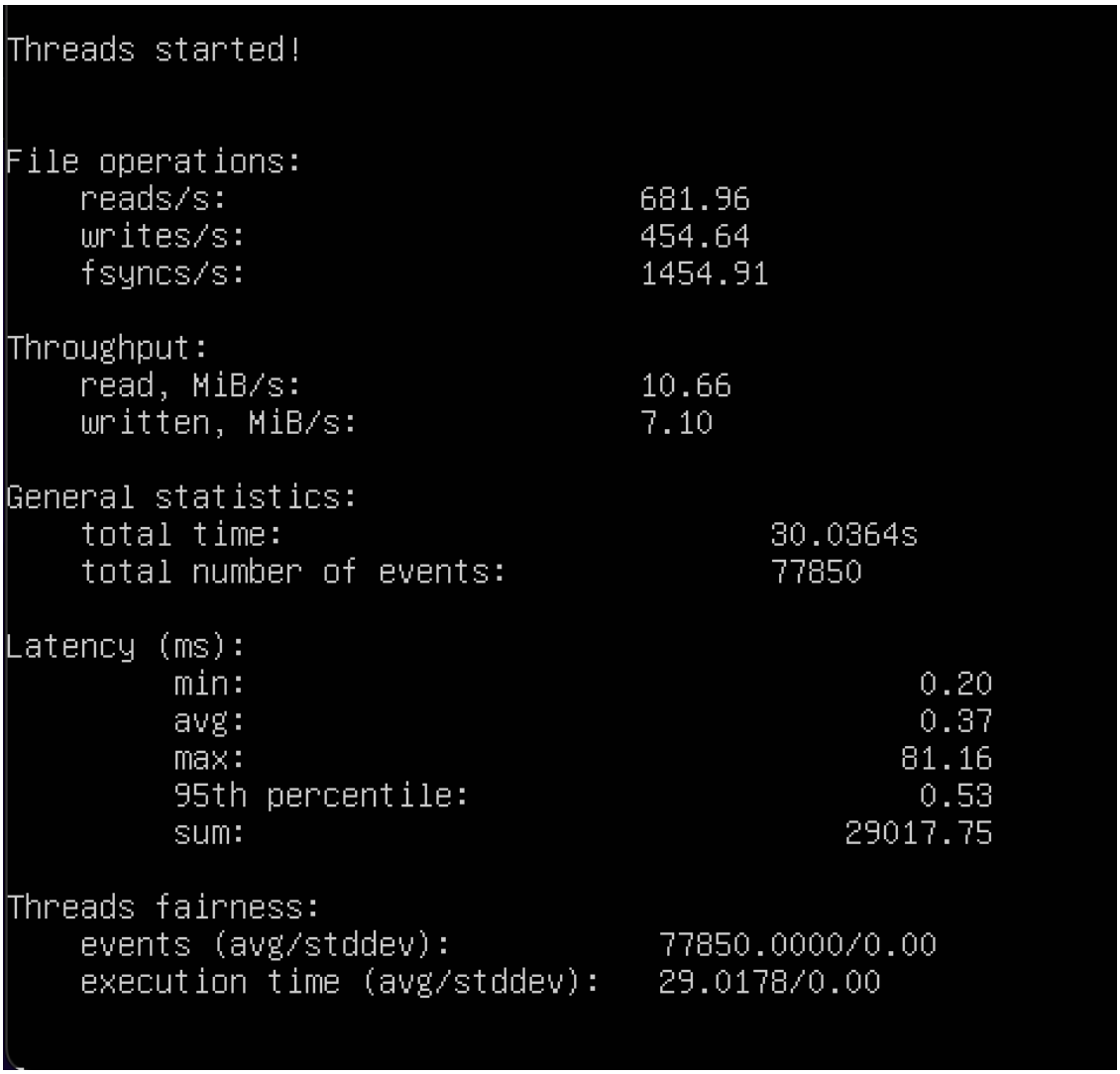

Threads started!
File operations:
reads/s: 682.22
writes/s: 454.80
fsyncs/s: 1458.03
Throughput:
read, MiB/s: 10.66
written, MiB/s: 7.11
General statistics:
total time: 30.0385s
total number of events: 78014
Latency (ms):
min: 0.19
avg: 0.37
max: 58.93
95th percentile: 0.60
sum: 29066.01
Threads fairness:
events (avg/stddev): 78014.0000/0.00
execution time (avg/stddev): 29.0660/0.00

Case 5:


Threads started!
File operations:
reads/s: 681.87
writes/s: 454.60
fsyncs/s: 1458.56
Throughput:
read, MiB/s: 10.65
written, MiB/s: 7.10
General statistics:
total time: 30.0395s
total number of events: 77985
Latency (ms):
min: 0.20
avg: 0.37
max: 83.50
95th percentile: 0.60
sum: 28956.97
Threads fairness:
events (avg/stddev): 77985.0000/0.00
execution time (avg/stddev): 28.9570/0.00

Scenario 2

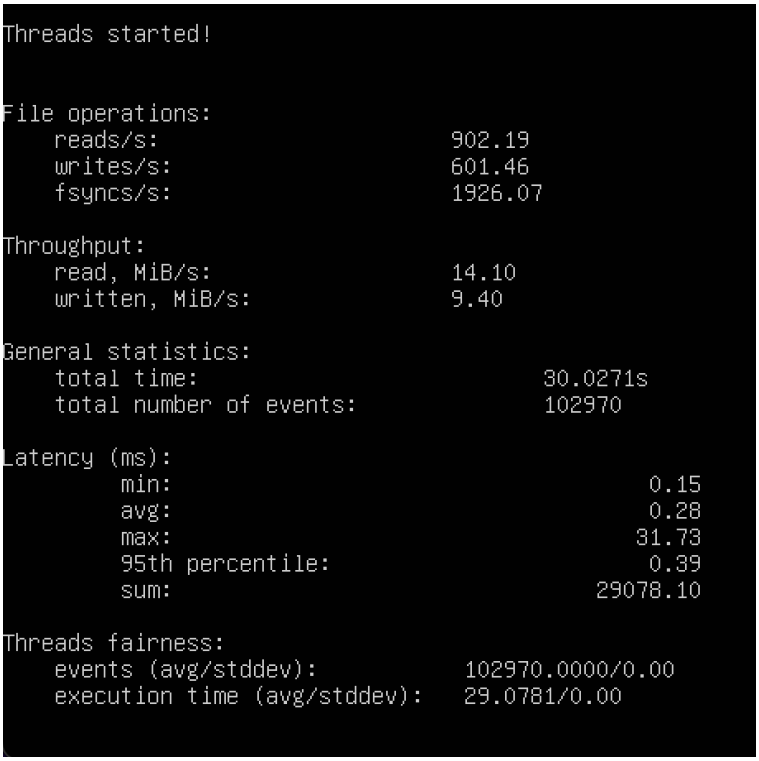
File size=3G
Case 1:



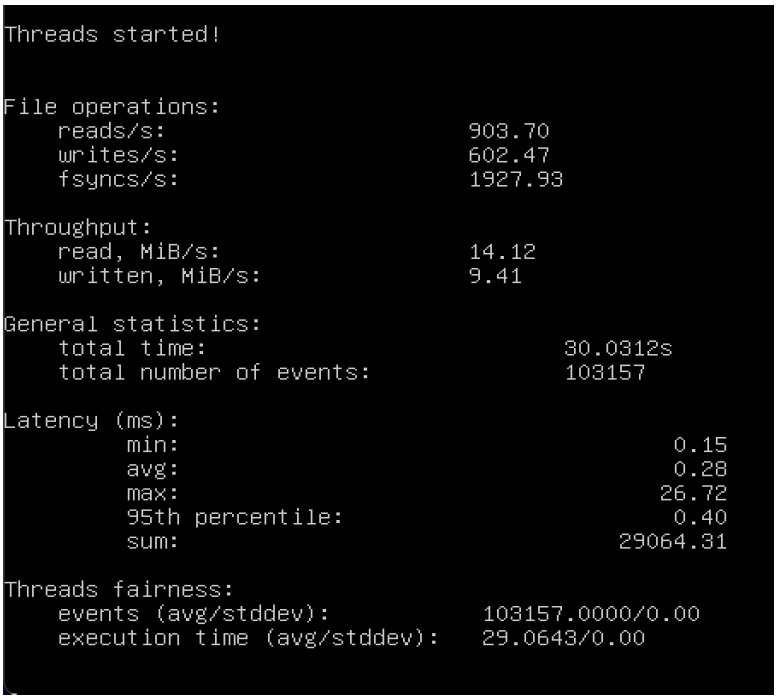
Case 2:


Threads started!
File operations:
reads/s: 696.27
writes/s: 464.18
fsyncs/s: 1485.57
Throughput:
read, MiB/s: 10.88
written, MiB/s: 7.25
General statistics:
total time: 30.0336s
total number of events: 79450
Latency (ms):
min: 0.20
avg: 0.36
max: 43.58
95th percentile: 0.60
sum: 28978.30
Threads fairness:
events (avg/stddev): 79450.0000/0.00
execution time (avg/stddev): 28.9783/0.00

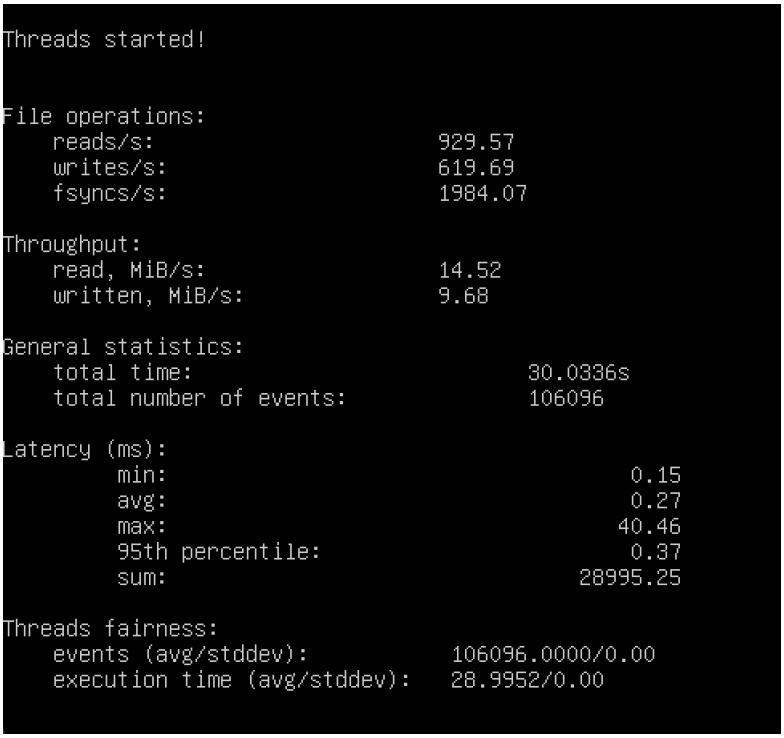
Case 3:


Threads started!
File operations:
reads/s: 902.19
writes/s: 601.46
fsyncs/s: 1926.07
Throughput:
read, MiB/s: 14.10
written, MiB/s: 9.40
General statistics:
total time: 30.0271s
total number of events: 102970
Latency (ms):
min: 0.15
avg: 0.28
max: 31.73
95th percentile: 0.39
sum: 29078.10
Threads fairness:
events (avg/stddev): 102970.0000/0.00
execution time (avg/stddev): 29.0781/0.00

Case 4:


Threads started!
File operations:
reads/s: 903.70
writes/s: 602.47
fsyncs/s: 1927.93
Throughput:
read, MiB/s: 14.12
written, MiB/s: 9.41
General statistics:
total time: 30.0312s
total number of events: 103157
Latency (ms):
min: 0.15
avg: 0.28
max: 26.72
95th percentile: 0.40
sum: 29064.31
Threads fairness:
events (avg/stddev): 103157.0000/0.00
execution time (avg/stddev): 29.0643/0.00

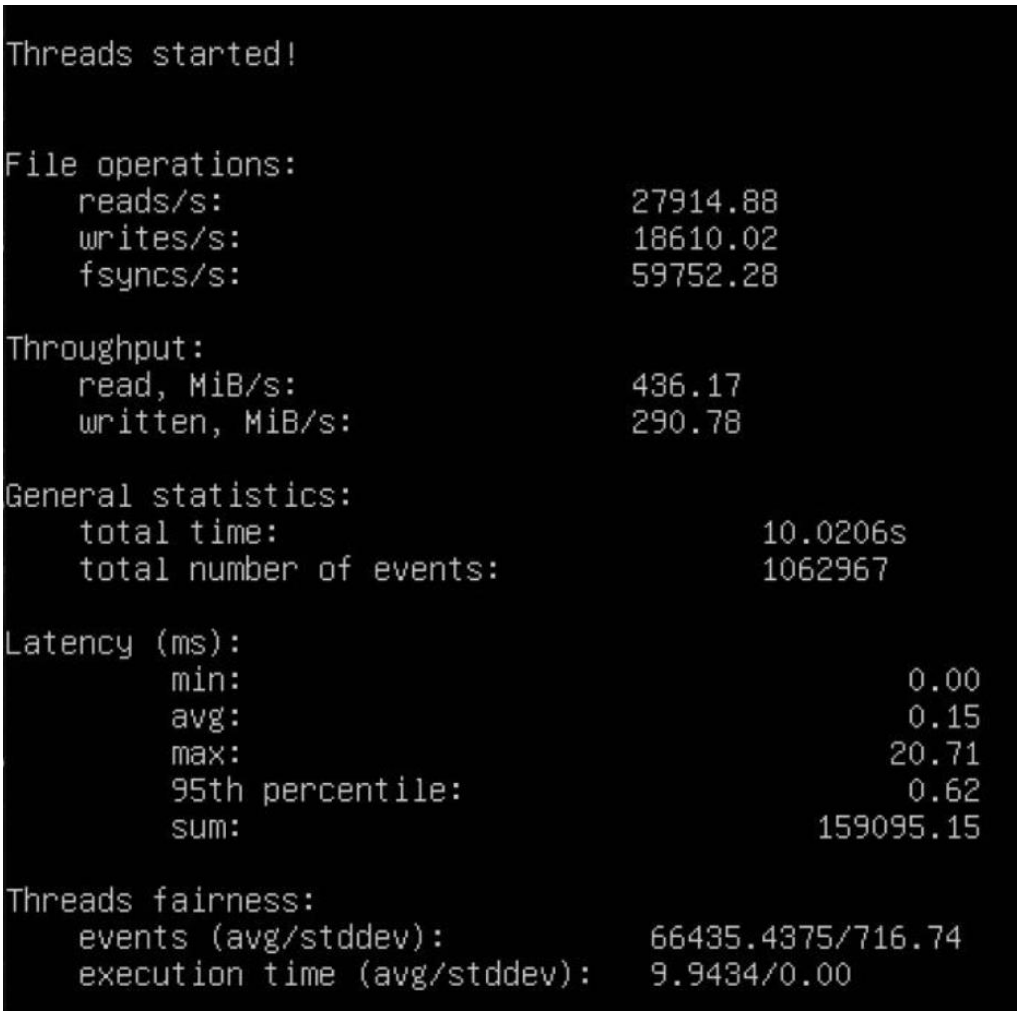
Case 5:


Threads started!
File operations:
reads/s: 929.57
writes/s: 619.69
fsyncs/s: 1984.07
Throughput:
read, MiB/s: 14.52
written, MiB/s: 9.68
General statistics:
total time: 30.0336s
total number of events: 106096
Latency (ms):
min: 0.15
avg: 0.27
max: 40.46
95th percentile: 0.37
sum: 28995.25
Threads fairness:
events (avg/stddev): 106096.0000/0.00
execution time (avg/stddev): 28.9952/0.00

Scenario 3

File size=4G

Case 1:



Case 2:

```
Threads started!


File operations:
    reads/s:                      31389.66
    writes/s:                     20926.50
    fsyncs/s:                     67164.08

Throughput:
    read, MiB/s:                  490.46
    written, MiB/s:               326.98

General statistics:
    total time:                          10.0201s
    total number of events:              1195215

Latency (ms):
         min:                                    0.00
         avg:                                    0.13
         max:                                    4.70
         95th percentile:                        0.57
         sum:                               158831.85

Threads fairness:
    events (avg/stddev):           74700.9375/848.63
    execution time (avg/stddev):   9.9270/0.00
```

Case 3:

```
Threads started!


File operations:
    reads/s:                      31478.15
    writes/s:                     20985.44
    fsyncs/s:                     67357.78

Throughput:
    read, MiB/s:                  491.85
    written, MiB/s:               327.90

General statistics:
    total time:                          10.0198s
    total number of events:              1198596

Latency (ms):
         min:                                    0.00
         avg:                                    0.13
         max:                                   15.50
         95th percentile:                        0.54
         sum:                               158877.39

Threads fairness:
    events (avg/stddev):           74912.2500/835.17
    execution time (avg/stddev):   9.9298/0.00
```

Case 4:

```
Threads started!


File operations:
    reads/s:                      23958.81
    writes/s:                     15972.54
    fsyncs/s:                     51307.14

Throughput:
    read, MiB/s:                  374.36
    written, MiB/s:               249.57

General statistics:
    total time:                          10.0292s
    total number of events:              913048

Latency (ms):
         min:                                    0.00
         avg:                                    0.17
         max:                                   17.10
         95th percentile:                        0.65
         sum:                               159534.14

Threads fairness:
    events (avg/stddev):           57065.5000/396.78
    execution time (avg/stddev):   9.9709/0.00
```

Case 5:

```
Threads started!


File operations:
    reads/s:                      18101.97
    writes/s:                     12067.98
    fsyncs/s:                     38819.26

Throughput:
    read, MiB/s:                  282.84
    written, MiB/s:               188.56

General statistics:
    total time:                          10.0228s
    total number of events:              689446

Latency (ms):
         min:                                    0.00
         avg:                                    0.23
         max:                                  193.36
         95th percentile:                        0.92
         sum:                               159336.13

Threads fairness:
    events (avg/stddev):           43090.3750/501.82
    execution time (avg/stddev):   9.9585/0.00
```

DOCKER CPU TESTING

Scenario 1

-cpu-max-prime=10000

Case 1:

```
root@331a1171499a:/# sh cpu_t1.sh
---------------
Docker CPU Test
---------------
Test Case: 1
WARNING: the --test option is deprecated. You can pass a
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:   771.08

General statistics:
    total time:                          10.0006s
    total number of events:              7713

Latency (ms):
         min:                                    1.17
         avg:                                    1.29
         max:                                   96.12
         95th percentile:                        1.47
         sum:                                 9984.26

Threads fairness:
    events (avg/stddev):           7713.0000/0.00
    execution time (avg/stddev):   9.9843/0.00
```

Case 2:

```
Test Case: 2
WARNING: the --test option is deprecated. You can pass a
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:   806.19

General statistics:
    total time:                          10.0005s
    total number of events:              8064

Latency (ms):
         min:                                    1.17
         avg:                                    1.24
         max:                                   13.75
         95th percentile:                        1.37
         sum:                                 9989.85

Threads fairness:
    events (avg/stddev):           8064.0000/0.00
    execution time (avg/stddev):   9.9898/0.00
```

Case 3:

```
Test Case: 3
WARNING: the --test option is deprecated. You can pass
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:   779.56

General statistics:
    total time:                          10.0009s
    total number of events:              7798

Latency (ms):
         min:                                    1.17
         avg:                                    1.28
         max:                                   43.04
         95th percentile:                        1.50
         sum:                                 9986.54

Threads fairness:
    events (avg/stddev):           7798.0000/0.00
    execution time (avg/stddev):   9.9865/0.00

Test Case: 4
```

Case 4:

```
Test Case: 4
WARNING: the --test option is deprecated. You can pass a
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:   804.14

General statistics:
    total time:                          10.0012s
    total number of events:              8044

Latency (ms):
         min:                                    1.17
         avg:                                    1.24
         max:                                    2.99
         95th percentile:                        1.42
         sum:                                 9990.59

Threads fairness:
    events (avg/stddev):           8044.0000/0.00
    execution time (avg/stddev):   9.9906/0.00
```

Case 5:

```
Test Case: 5
WARNING: the --test option is deprecated. You can pass a
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:   797.98

General statistics:
    total time:                          10.0003s
    total number of events:              7982

Latency (ms):
         min:                                    1.16
         avg:                                    1.25
         max:                                    6.54
         95th percentile:                        1.39
         sum:                                 9988.27

Threads fairness:
    events (avg/stddev):           7982.0000/0.00
    execution time (avg/stddev):   9.9883/0.00

root@331a1171499a:/#
```

Scenario 2

-cpu-max-prime=30000
Case 1:

```
---------
DOCKER CPU Test
---------
Test Case: 1
WARNING: the --test option is deprecated. You can pass
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:   165.76

General statistics:
    total time:                          10.0004s
    total number of events:              1658

Latency (ms):
         min:                                    5.38
         avg:                                    6.03
         max:                                   56.67
         95th percentile:                        7.43
         sum:                                 9994.32

Threads fairness:
    events (avg/stddev):           1658.0000/0.00
    execution time (avg/stddev):   9.9943/0.00

Test Case: 2
```

Case 2:

```
Test Case: 2
WARNING: the --test option is deprecated. You can pass
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:   179.83

General statistics:
    total time:                          10.0016s
    total number of events:              1799

Latency (ms):
         min:                                    5.38
         avg:                                    5.56
         max:                                   22.87
         95th percentile:                        5.88
         sum:                                 9996.43

Threads fairness:
    events (avg/stddev):           1799.0000/0.00
    execution time (avg/stddev):   9.9964/0.00
```

Case 3:

```
Test Case: 3
WARNING: the --test option is deprecated. You can pass
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:   176.92

General statistics:
    total time:                          10.0025s
    total number of events:              1770

Latency (ms):
         min:                                    5.38
         avg:                                    5.65
         max:                                   29.13
         95th percentile:                        6.21
         sum:                                 9995.98

Threads fairness:
    events (avg/stddev):           1770.0000/0.00
    execution time (avg/stddev):   9.9960/0.00
```

Case 4:

```
Test Case: 4
WARNING: the --test option is deprecated. You can pass
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:   176.54

General statistics:
    total time:                          10.0005s
    total number of events:              1766

Latency (ms):
         min:                                    5.38
         avg:                                    5.66
         max:                                   19.48
         95th percentile:                        6.43
         sum:                                 9994.41

Threads fairness:
    events (avg/stddev):           1766.0000/0.00
    execution time (avg/stddev):   9.9944/0.00
```

Case 5:

```
Test Case: 5
WARNING: the --test option is deprecated. You can pass
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:   175.88

General statistics:
    total time:                          10.0045s
    total number of events:              1760

Latency (ms):
         min:                                    5.38
         avg:                                    5.68
         max:                                   20.67
         95th percentile:                        6.21
         sum:                                 9998.11

Threads fairness:
    events (avg/stddev):           1760.0000/0.00
    execution time (avg/stddev):   9.9981/0.00
```

Scenario 3

-cpu-max-prime=50000

Case 1:

```
---------
DOCKER CPU Test
---------
Test Case: 1
WARNING: the --test option is deprecated. You can pass
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:    90.16

General statistics:
    total time:                          10.0027s
    total number of events:              902

Latency (ms):
         min:                                    10.72
         avg:                                    11.09
         max:                                    24.78
         95th percentile:                        11.65
         sum:                                  9999.48

Threads fairness:
    events (avg/stddev):           902.0000/0.00
    execution time (avg/stddev):   9.9995/0.00
```

Case 2:

```
Test Case: 2
WARNING: the --test option is deprecated. You can pass
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:    89.02

General statistics:
    total time:                          10.0069s
    total number of events:              891

Latency (ms):
         min:                                    10.88
         avg:                                    11.23
         max:                                    28.19
         95th percentile:                        11.87
         sum:                                 10003.01

Threads fairness:
    events (avg/stddev):           891.0000/0.00
    execution time (avg/stddev):   10.0030/0.00
```

Case 3:

```
Test Case: 3
WARNING: the --test option is deprecated. You can pass
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:    87.42

General statistics:
    total time:                          10.0071s
    total number of events:              875

Latency (ms):
         min:                                    10.88
         avg:                                    11.43
         max:                                    30.38
         95th percentile:                        12.75
         sum:                                 10002.84

Threads fairness:
    events (avg/stddev):           875.0000/0.00
    execution time (avg/stddev):   10.0028/0.00
```

Case 4:

```
Test Case: 4
WARNING: the --test option is deprecated. You can pass
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:    87.49

General statistics:
    total time:                          10.0106s
    total number of events:              876

Latency (ms):
         min:                                    10.88
         avg:                                    11.42
         max:                                    27.25
         95th percentile:                        12.30
         sum:                                 10005.82

Threads fairness:
    events (avg/stddev):           876.0000/0.00
    execution time (avg/stddev):   10.0058/0.00
```

Case 5:

```
Test Case: 5
WARNING: the --test option is deprecated. You can pass
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:    88.15

General statistics:
    total time:                          10.0037s
    total number of events:              882

Latency (ms):
         min:                                    10.87
         avg:                                    11.34
         max:                                    32.50
         95th percentile:                        12.08
         sum:                                  9998.47

Threads fairness:
    events (avg/stddev):           882.0000/0.00
    execution time (avg/stddev):   9.9985/0.00
```

DOCKER FILE I/O TESTING

Scenario 1

File size=2G

Case 1:

```
Threads started!


File operations:
    reads/s:                      1318.65
    writes/s:                     879.09
    fsyncs/s:                     2814.04

Throughput:
    read, MiB/s:                  20.60
    written, MiB/s:               13.74

General statistics:
    total time:                          30.0190s
    total number of events:              150330

Latency (ms):
         min:                                    0.05
         avg:                                    0.20
         max:                                   30.44
         95th percentile:                        0.39
         sum:                                29866.83

Threads fairness:
    events (avg/stddev):           150330.0000/0.00
    execution time (avg/stddev):   29.8668/0.00
```

Case 2:

```
Threads started!


File operations:
    reads/s:                      1247.23
    writes/s:                     831.49
    fsyncs/s:                     2663.69

Throughput:
    read, MiB/s:                  19.49
    written, MiB/s:               12.99

General statistics:
    total time:                          30.0166s
    total number of events:              142232

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                  221.18
         95th percentile:                        0.40
         sum:                                29872.72

Threads fairness:
    events (avg/stddev):           142232.0000/0.00
    execution time (avg/stddev):   29.8727/0.00
```

Case 3:

```
Threads started!


File operations:
    reads/s:                      1272.32
    writes/s:                     848.19
    fsyncs/s:                     2716.12

Throughput:
    read, MiB/s:                  19.88
    written, MiB/s:               13.25

General statistics:
    total time:                          30.0174s
    total number of events:              145064

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                  107.90
         95th percentile:                        0.39
         sum:                                29869.52

Threads fairness:
    events (avg/stddev):           145064.0000/0.00
    execution time (avg/stddev):   29.8695/0.00
```

Case 4:

```
Threads started!


File operations:
    reads/s:                      1298.05
    writes/s:                     865.34
    fsyncs/s:                     2771.44

Throughput:
    read, MiB/s:                  20.28
    written, MiB/s:               13.52

General statistics:
    total time:                          30.0186s
    total number of events:              148018

Latency (ms):
         min:                                    0.05
         avg:                                    0.20
         max:                                   34.31
         95th percentile:                        0.39
         sum:                                29866.60

Threads fairness:
    events (avg/stddev):           148018.0000/0.00
    execution time (avg/stddev):   29.8666/0.00
```

Case 5:

```
Threads started!


File operations:
    reads/s:                      1231.26
    writes/s:                     820.84
    fsyncs/s:                     2626.86

Throughput:
    read, MiB/s:                  19.24
    written, MiB/s:               12.83

General statistics:
    total time:                          30.0160s
    total number of events:              140325

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                   61.23
         95th percentile:                        0.40
         sum:                                29871.20

Threads fairness:
    events (avg/stddev):           140325.0000/0.00
    execution time (avg/stddev):   29.8712/0.00
```

Scenario 2

File size=3G

Case 1:

```
Threads started!


File operations:
    reads/s:                      1413.14
    writes/s:                     942.09
    fsyncs/s:                     3018.50

Throughput:
    read, MiB/s:                  22.08
    written, MiB/s:               14.72

General statistics:
    total time:                          30.0163s
    total number of events:              161182

Latency (ms):
         min:                                    0.05
         avg:                                    0.19
         max:                                   51.52
         95th percentile:                        0.39
         sum:                                29851.06

Threads fairness:
    events (avg/stddev):           161182.0000/0.00
    execution time (avg/stddev):   29.8511/0.00
```

Case 2:

```
Threads started!


File operations:
    reads/s:                      1249.07
    writes/s:                     832.71
    fsyncs/s:                     2666.38

Throughput:
    read, MiB/s:                  19.52
    written, MiB/s:               13.01

General statistics:
    total time:                          30.0973s
    total number of events:              142788

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                   60.49
         95th percentile:                        0.40
         sum:                                29886.30

Threads fairness:
    events (avg/stddev):           142788.0000/0.00
    execution time (avg/stddev):   29.8863/0.00
```

Case 3:

```
Threads started!


File operations:
    reads/s:                      1115.43
    writes/s:                     743.64
    fsyncs/s:                     2383.49

Throughput:
    read, MiB/s:                  17.43
    written, MiB/s:               11.62

General statistics:
    total time:                          30.0180s
    total number of events:              127233

Latency (ms):
         min:                                    0.05
         avg:                                    0.23
         max:                                   72.99
         95th percentile:                        0.42
         sum:                                29876.50

Threads fairness:
    events (avg/stddev):           127233.0000/0.00
    execution time (avg/stddev):   29.8765/0.00
```

Case 4:

```
Threads started!


File operations:
    reads/s:                      1246.80
    writes/s:                     831.19
    fsyncs/s:                     2660.55

Throughput:
    read, MiB/s:                  19.48
    written, MiB/s:               12.99

General statistics:
    total time:                          30.0190s
    total number of events:              142127

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                   43.86
         95th percentile:                        0.39
         sum:                                29867.93

Threads fairness:
    events (avg/stddev):           142127.0000/0.00
    execution time (avg/stddev):   29.8679/0.00
```

Case 5:

```
Threads started!


File operations:
    reads/s:                      1226.83
    writes/s:                     817.91
    fsyncs/s:                     2618.15

Throughput:
    read, MiB/s:                  19.17
    written, MiB/s:               12.78

General statistics:
    total time:                          30.0163s
    total number of events:              139843

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                   88.02
         95th percentile:                        0.40
         sum:                                29879.98

Threads fairness:
    events (avg/stddev):           139843.0000/0.00
    execution time (avg/stddev):   29.8800/0.00
```

Scenario 3

File size=4G

Case 1:

```
Threads started!


File operations:
    reads/s:                      1201.24
    writes/s:                     800.81
    fsyncs/s:                     2566.84

Throughput:
    read, MiB/s:                  18.77
    written, MiB/s:               12.51

General statistics:
    total time:                          30.0178s
    total number of events:              137029

Latency (ms):
         min:                                    0.05
         avg:                                    0.22
         max:                                   48.68
         95th percentile:                        0.40
         sum:                                29878.58

Threads fairness:
    events (avg/stddev):           137029.0000/0.00
    execution time (avg/stddev):   29.8786/0.00
```

Case 2:

```
Threads started!


File operations:
    reads/s:                      1156.49
    writes/s:                     771.00
    fsyncs/s:                     2468.60

Throughput:
    read, MiB/s:                  18.07
    written, MiB/s:               12.05

General statistics:
    total time:                          30.0200s
    total number of events:              131851

Latency (ms):
         min:                                    0.05
         avg:                                    0.23
         max:                                   27.91
         95th percentile:                        0.42
         sum:                                29879.73

Threads fairness:
    events (avg/stddev):           131851.0000/0.00
    execution time (avg/stddev):   29.8797/0.00
```

Case 3:

```
Threads started!


File operations:
    reads/s:                      1160.94
    writes/s:                     773.97
    fsyncs/s:                     2477.24

Throughput:
    read, MiB/s:                  18.14
    written, MiB/s:               12.09

General statistics:
    total time:                          30.0186s
    total number of events:              132327

Latency (ms):
         min:                                    0.05
         avg:                                    0.23
         max:                                   76.81
         95th percentile:                        0.41
         sum:                                29871.63

Threads fairness:
    events (avg/stddev):           132327.0000/0.00
    execution time (avg/stddev):   29.8716/0.00
```

Case 4:

```
Threads started!


File operations:
    reads/s:                      1314.74
    writes/s:                     876.51
    fsyncs/s:                     2805.27

Throughput:
    read, MiB/s:                  20.54
    written, MiB/s:               13.70

General statistics:
    total time:                          30.0216s
    total number of events:              149885

Latency (ms):
         min:                                    0.05
         avg:                                    0.20
         max:                                   26.38
         95th percentile:                        0.39
         sum:                                29863.57

Threads fairness:
    events (avg/stddev):           149885.0000/0.00
    execution time (avg/stddev):   29.8636/0.00
```

Case 5:

```
Threads started!


File operations:
    reads/s:                      1236.15
    writes/s:                     824.07
    fsyncs/s:                     2639.17

Throughput:
    read, MiB/s:                  19.31
    written, MiB/s:               12.88

General statistics:
    total time:                          30.0197s
    total number of events:              140955

Latency (ms):
         min:                                    0.05
         avg:                                    0.21
         max:                                   40.90
         95th percentile:                        0.40
         sum:                                29871.29

Threads fairness:
    events (avg/stddev):           140955.0000/0.00
    execution time (avg/stddev):   29.8713/0.00
```

A) CPU Performance Results:

- **QEMU**

Scenario 1

Case	Total Time(s)	CPU Speed(events/s)	Avg. Latency(ms)
1	10.0029	277.65	3.58
2	10.0036	275.23	3.61
3	10.0011	273.41	3.64
4	10.0023	265.97	3.73
5	10.0016	278.58	3.57
Minimum	10.0011	265.97	3.57
Maximum	10.0036	278.58	3.73
Average	10.0023143	273.627143	3.63285714
StdDev	0.0009975	5.01247643	0.06420508

Scenario 2

Case	Total Time(s)	CPU Speed(events/s)	Avg. Latency(ms)
1	10.0137	58.26	17.08
2	10.0116	62.49	15.94
3	10.0098	60.4	16.49
4	10.004	61.64	16.16
5	10.0026	58.65	16.98
Minimum	10.0026	58.26	15.94
Maximum	10.0137	62.49	17.08
Average	10.0082857	60.3128571	16.5242857
StdDev	0.00482887	1.83610185	0.49789557

Scenario 3

Case	Total Time(s)	CPU Speed(events/s)	Avg. Latency(ms)
1	10.0199	31.42	31.67
2	10.0282	30.96	32.16
3	10.0288	30.59	32.58
4	10.0148	30.74	32.44
5	10.0027	30.97	32.19
Minimum	10.0027	30.59	31.67
Maximum	10.0288	31.42	32.58
Average	10.0179857	30.9557143	32.1842857
StdDev	0.01077901	0.31389489	0.34795115

- **Docker**

Scenario 1

Case	Total Time(s)	CPU Speed(events/s)	Avg. Latency(ms)
1	10.0006	771.08	1.29
2	10.0005	806.19	1.24
3	10.0009	779.56	1.28
4	10.0012	804.14	1.24
5	10.0003	797.98	1.25
Minimum	10.0003	771.08	1.24
Maximum	10.0012	806.19	1.29
Average	10.0007143	790.888571	1.26142857
StdDev	0.00035355	15.6259048	0.02345208

Scenario 2

Case	Total Time(s)	CPU Speed(events/s)	Avg. Latency (ms)
1	10.0004	165.76	6.03
2	10.0016	179.83	5.56
3	10.0025	176.92	5.65
4	10.0005	176.54	5.66
5	10.0045	175.88	5.68
Minimum	10.0004	165.76	5.56
Maximum	10.0045	179.83	6.03
Average	10.0020571	174.36	5.73857143
StdDev	0.00168967	5.37442834	0.18146625

Scenario 3

Case	Total Time(s)	CPU Speed(events/s)	Avg. Latency(ms)
1	10.0027	90.16	11.09
2	10.0069	89.02	11.23
3	10.0071	87.42	11.43
4	10.0106	87.49	11.42
5	10.0037	88.15	11.34
Minimum	10.0027	87.42	11.09
Maximum	10.0106	90.16	11.43
Average	10.0063286	88.5457143	11.29
StdDev	0.0031289	1.15341666	0.14307341

B) File IO Performance

- **QEMU**

Scenario 1

Case	Read Throughput(MiB/S)	Write Throughput(MiB/S)	Avg. Latency(ms)
1	11.26	7.5	0.35
2	10.13	6.75	0.39
3	10.54	7.03	0.38
4	10.66	7.11	0.37
5	10.65	7.1	0.37
Minimum	10.13	6.75	0.35
Maximum	11.26	7.5	0.39
Average	10.6614286	7.10571429	0.37142857
StdDev	0.40456149	0.26808581	0.0148324

Scenario 2

Case	Read Throughput(MiB/S)	Write Throughput(MiB/S)	Avg. Latency(ms)
1	10.66	7.1	0.37
2	10.88	7.25	0.36
3	14.1	9.4	0.28
4	14.12	9.41	0.28
5	14.52	9.68	0.27
Minimum	10.66	7.1	0.27
Maximum	14.52	9.68	0.37
Average	12.78	8.51714286	0.31428571
StdDev	1.91318582	1.27768149	0.04868265

Scenario 3

Case	Read Throughput(MiB/S)	Write Throughput(MiB/S)	Avg. Latency(ms)
1	436.17	290.78	0.15
2	490.46	326.98	0.13
3	491.85	327.9	0.13
4	374.36	249.57	0.17
5	282.84	188.56	0.23
Minimum	282.84	188.56	0.13
Maximum	491.85	327.9	0.23
Average	407.195714	271.464286	0.16714286
StdDev	88.2695952	58.8482041	0.04147288

- **Docker**

Scenario 1

Case	Read Throughput(MiB/S)	Write Throughput(MiB/S)	Avg. Latency(ms)
1	20.6	13.74	0.2
2	19.49	12.99	0.21
3	19.88	13.25	0.21
4	20.28	13.52	0.2
5	19.24	12.83	0.21
Minimum	19.24	12.83	0.2
Maximum	20.6	13.74	0.21
Average	19.9042857	13.2714286	0.20571429
StdDev	0.55643508	0.37273315	0.00547723

Scenario 2

Case	Read Throughput(MiB/S)	Write Throughput(MiB/S)	Avg. Latency(ms)
1	22.08	14.72	0.19
2	19.52	13.01	0.21
3	17.43	11.62	0.23
4	19.48	12.99	0.21
5	19.17	12.78	0.21
Minimum	17.43	11.62	0.19
Maximum	22.08	14.72	0.23
Average	19.5985714	13.0657143	0.21
StdDev	1.66166483	1.107759	0.01414214

Scenario 3

Case	Read Throughput(MiB/S)	Write Throughput(MiB/S)	Avg. Latency(ms)
1	18.77	12.51	0.22
2	18.07	12.05	0.23
3	18.14	12.09	0.23
4	20.54	13.7	0.2
5	19.31	12.88	0.21
Minimum	18.07	12.05	0.2
Maximum	20.54	13.7	0.23
Average	19.0628571	12.7114286	0.21714286
StdDev	1.0148054	0.67980144	0.0130384

CONCLUDING REMARKS:

From the above results we observe that QEMU and Docker, both perform equally in CPU performance in all 3 scenarios. In the File I/O test, QEMU performs slightly better than Docker in all 3 scenarios.