

# **COEN -241 Cloud Computing**

## **Homework1: System Vs OS Virtualization Report**

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## **HW Github link:**

## **Github Link for HW**

### **Host System Configuration:**

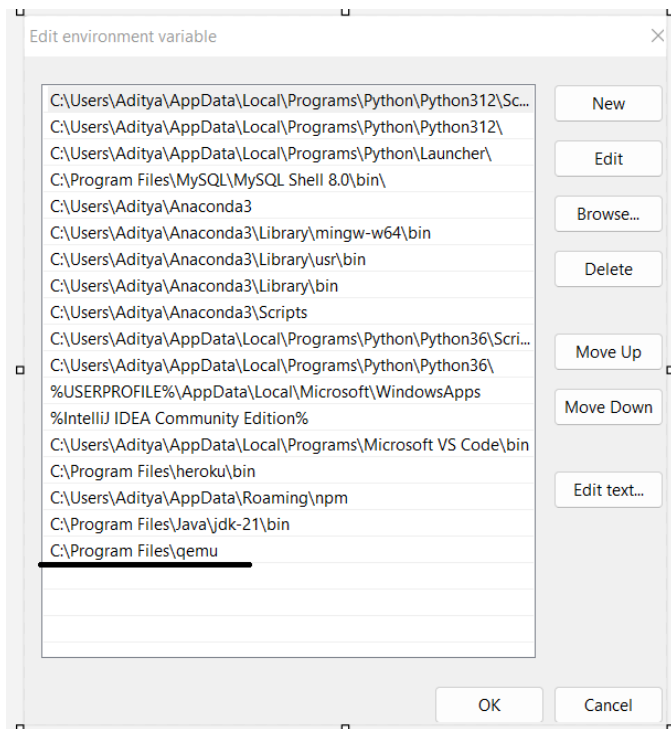
1	Processor	11th Gen Intel(R) Core(TM) i5-1155G7 @ 2.50GHz 2.50 GHz
2	CPU	10
3	Memory	8 GB
4	Free disk space	143 GB
5	Operating System	Windows 11

- We will be using two different disk images for QEMU namely raw and qcow2 with four different configurations which will be seen in the report further.
- We will also use four Docker which will again be seen further in the report.

### **QEMU and Ubuntu Installation and setup:**

In this section we will discuss about the process of QEMU Installation and setup:

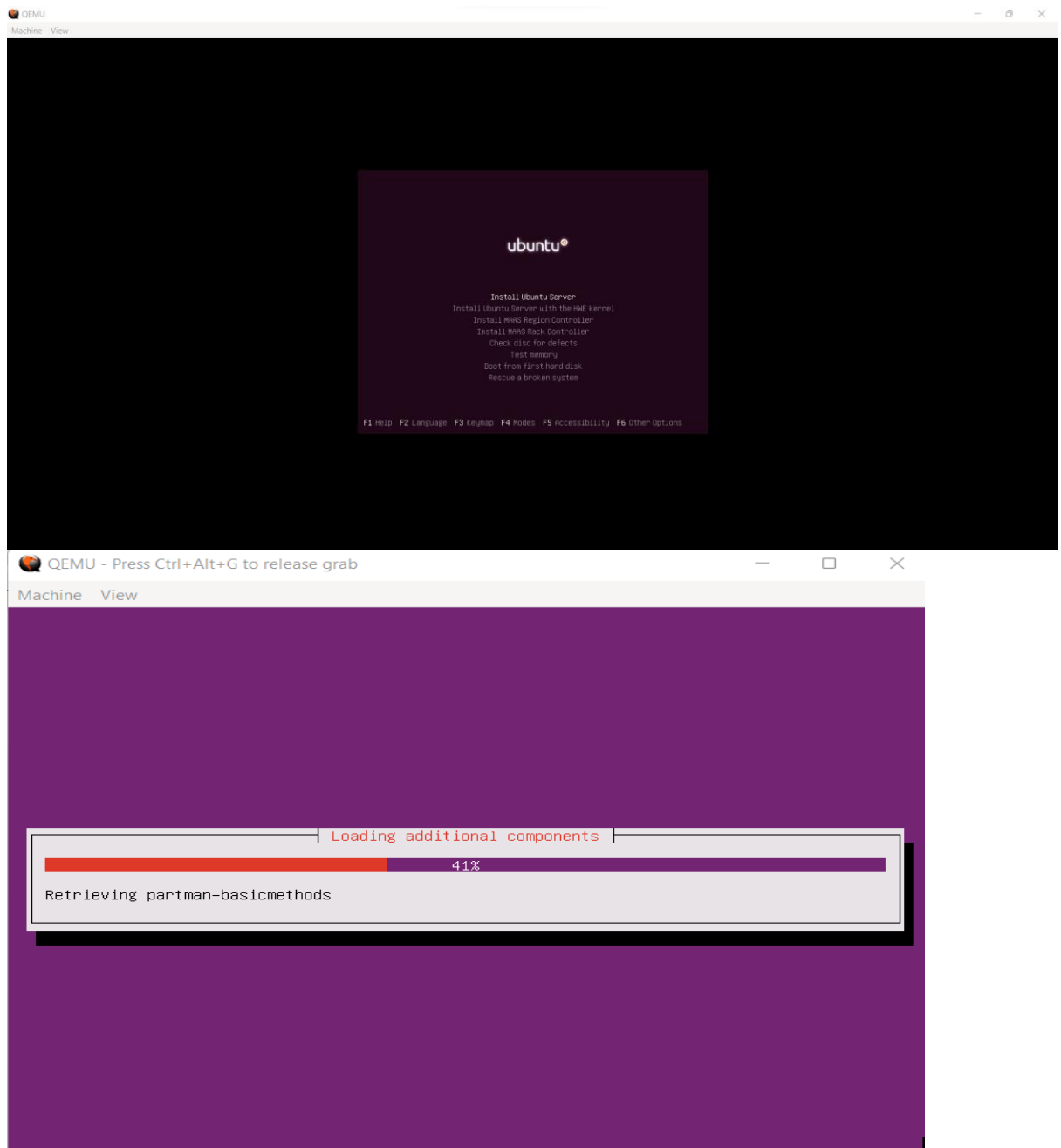
- 1) Download QEMU for windows from the link: [QEMU Downloader](#)
- 2) Then download Ubuntu 16.04 server ISO image to run ubuntu guest virtual Machine from the link: [Ubuntu 16.04 Server](#)
- 3) Then the next step is to add QEMU path to the path system variable section in the environment variables.



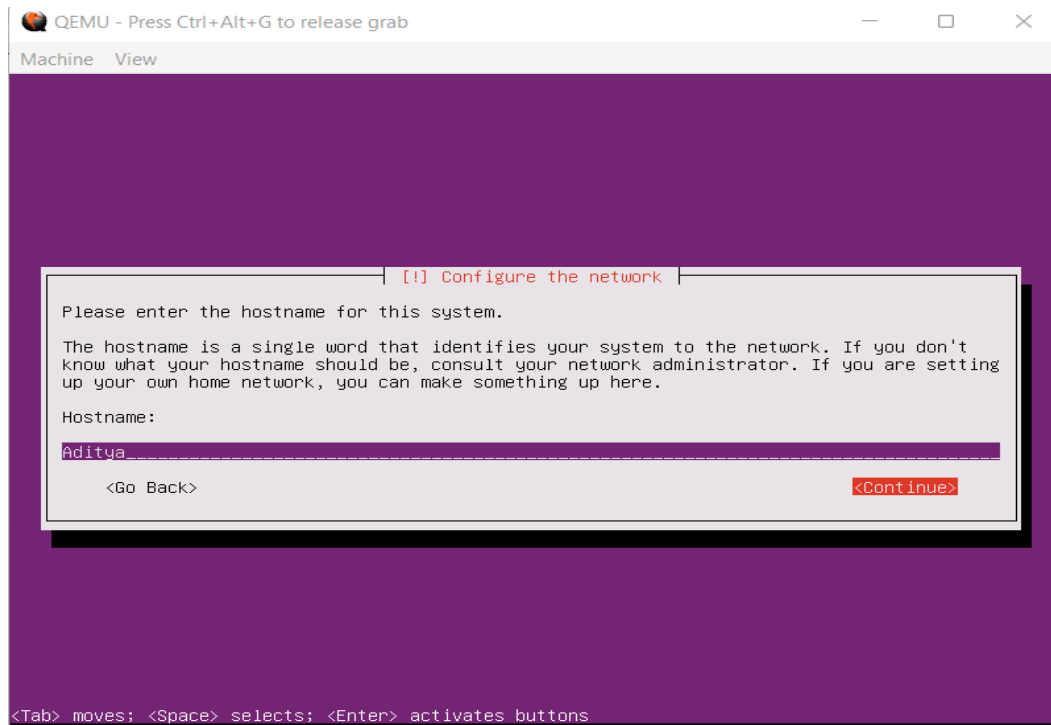
4) Once QEMU path has been added to the environment variables then open the PowerShell as administrator and the run the following commands.

- Open the QEMU folder in PowerShell using **cd \qemu**
- After that create an Ubuntu image in qcow2 file format with a virtual hard drive of 30 GB and the command to execute this is: **qemu-img create -f qcow2 ubuntu20.img 30G**
- Now run the Ubuntu using CD-ROM with command: **qemu-system-x86\_64.exe -m 1G -smp 2 -boot order=dc -hda ubuntu20.img -cdrom "e:\ubuntu-20.04.3-desktop-amd64.iso"**
- This will start the ubuntu installation. Below are the screenshots for Ubuntu installation.

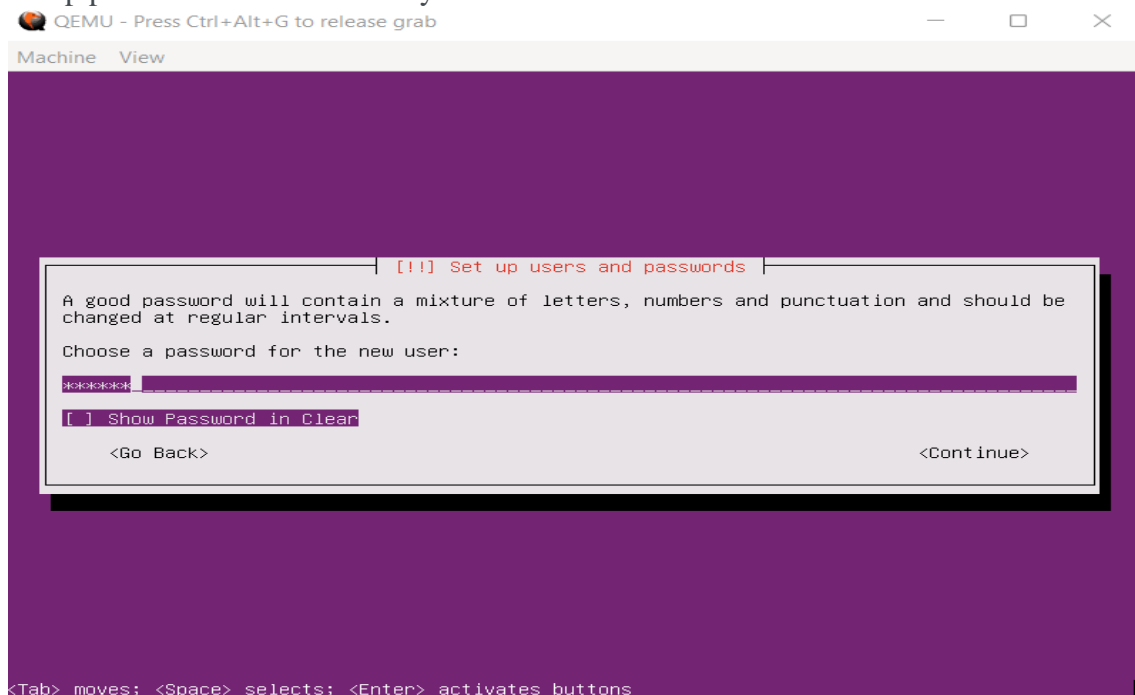




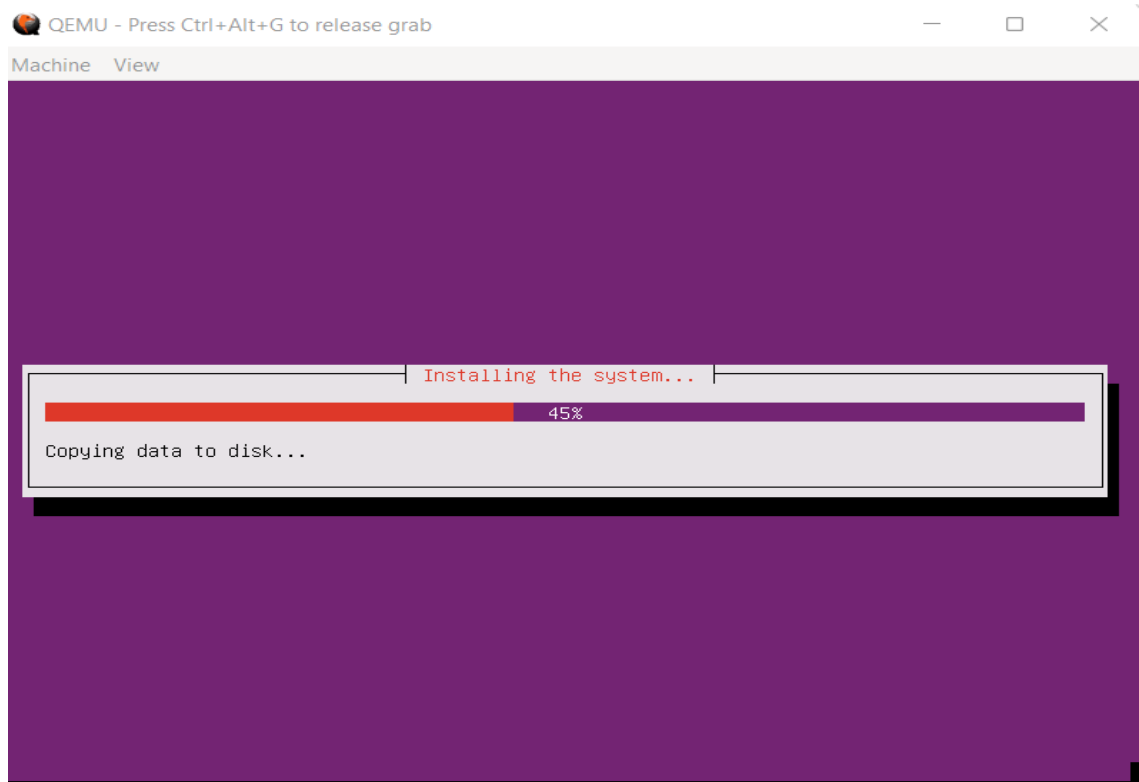
- Enter hostname for the ubuntu system.



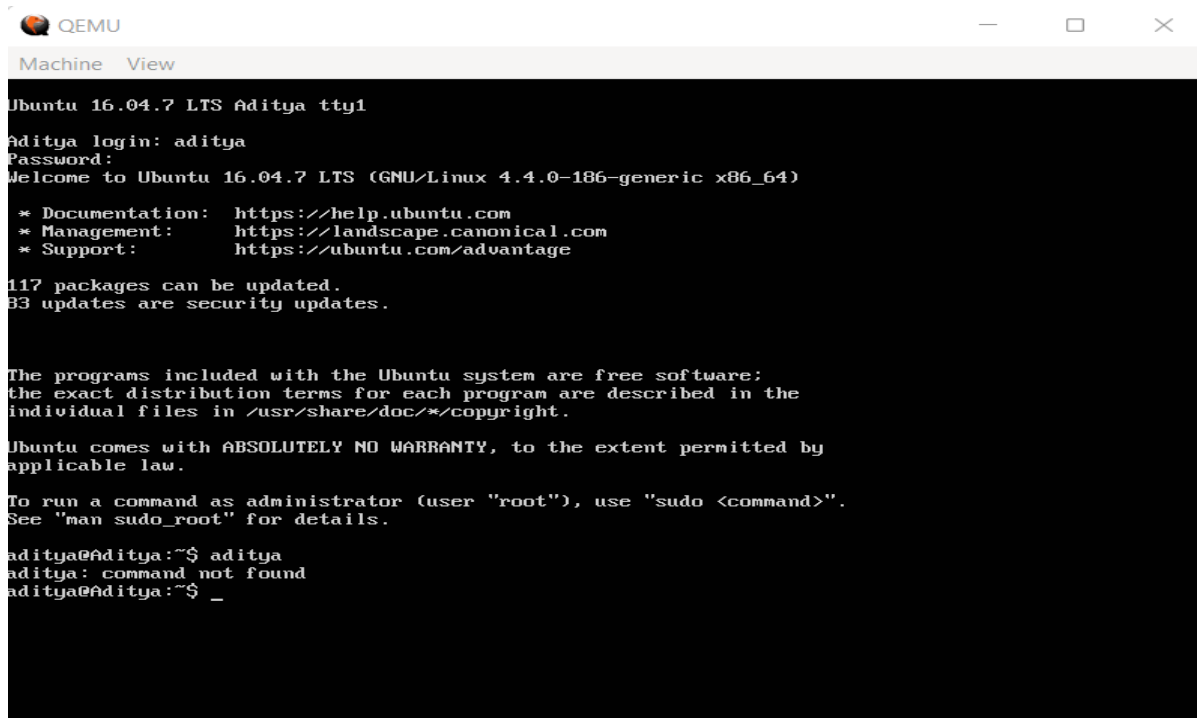
- Setup password for the ubuntu system.



- System installation starts



- Once installation gets completed check the ubuntu version to verify if ubuntu has been installed successfully.



- 5) Now install sysbench on QEMU to do this run the following commands:
- ```
sudo apt-get update  
sudo apt install sysbench
```

```
QEMU - Press Ctrl+Alt+G to release grab

Machine View

buntu 16.04.7 LTS Aditya tty1

aditya login: aditya
password:
Last login: Mon Jan 29 22:14:37 PST 2024 on tty1
Welcome to Ubuntu 16.04.7 LTS (GNU/Linux 4.4.0-186-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

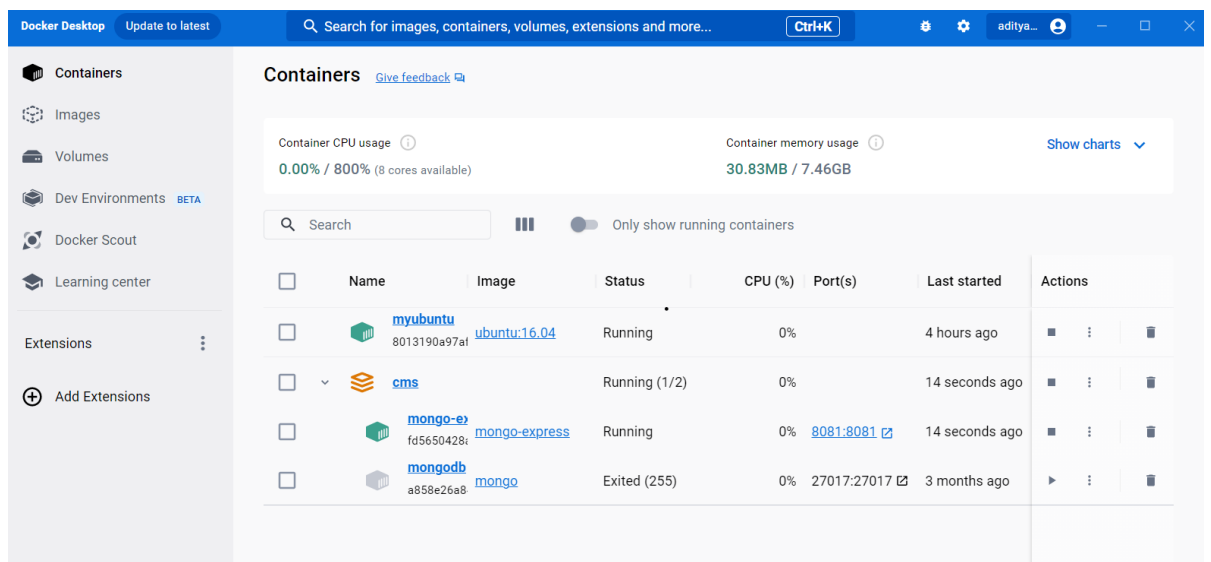
17 packages can be updated.
3 updates are security updates.

New release '18.04.6 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

aditya@Aditya:~$ sysbench --version
sysbench 0.4.12
aditya@Aditya:~$
```

## Docker Installation and Setup:

1. Firstly, install docker desktop from the official docker website.



2. Open command prompt and download the ubuntu base image from docker hub using command: **docker pull ubuntu:16.04**

```
C:\windows\system32\cmd.exe
Microsoft Windows [Version 10.0.22000.2538]
(c) Microsoft Corporation. All rights reserved.

C:\Users\Aditya>docker pull ubuntu:16.04
16.04: Pulling from library/ubuntu
Digest: sha256:1f1a2d56de1d604801a9671f301190704c25d604a416f59e03c04f5c6ffee0d6
Status: Image is up to date for ubuntu:16.04
docker.io/library/ubuntu:16.04

What's Next?
  View a summary of image vulnerabilities and recommendations → docker scout quickview ubuntu:16.04

C:\Users\Aditya>
```

3. Now spin up an Ubuntu container with 4GB of RAM and 2 CPU cores using the command:

**docker run -it --name myubuntu -m 4g --cpus=2 ubuntu:16.04**

```
root@20ed21eda30d: /
Microsoft Windows [Version 10.0.22000.2538]
(c) Microsoft Corporation. All rights reserved.

C:\Users\Aditya>docker pull ubuntu:16.04
16.04: Pulling from library/ubuntu
Digest: sha256:1f1a2d56de1d604801a9671f301190704c25d604a416f59e03c04f5c6ffee0d6
Status: Image is up to date for ubuntu:16.04
docker.io/library/ubuntu:16.04

What's Next?
  View a summary of image vulnerabilities and recommendations → docker scout quickview ubuntu:16.04

C:\Users\Aditya>docker run -it --name myubuntu -m 2g --cpus=2 ubuntu:16.04
root@20ed21eda30d: /#
```

4. Install nano on docker using the command: **apt-get install nano**
5. Also install sysbench on docker using command: **apt install sysbench**



```
root@20ed21eda30d: /
unpacking libssl1.0.0:amd64 (1.0.2g-1ubuntu4.20) ...
selecting previously unselected package mysql-common.
preparing to unpack .../mysql-common_5.7.33-0ubuntu0.16.04.1_all.deb ...
unpacking mysql-common (5.7.33-0ubuntu0.16.04.1) ...
selecting previously unselected package libmysqlclient20:amd64.
preparing to unpack .../libmysqlclient20_5.7.33-0ubuntu0.16.04.1_amd64.deb ...
unpacking libmysqlclient20:amd64 (5.7.33-0ubuntu0.16.04.1) ...
selecting previously unselected package sysbench.
preparing to unpack .../sysbench_0.4.12-1.1ubuntu1_amd64.deb ...
unpacking sysbench (0.4.12-1.1ubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu11.3) ...
setting up libssl1.0.0:amd64 (1.0.2g-1ubuntu4.20) ...
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based frontend cannot be used. at /usr/share/perl5/Debconf/FrontEnd/Dialog.pm line 76.)
debconf: falling back to frontend: Readline
debconf: unable to initialize frontend: Readline
debconf: (Can't locate Term/ReadLine.pm in @INC (you may need to install the Term::ReadLine module) (@INC contains: /etc/perl /usr/local/lib/x86_64-linux-gnu/perl/5.22.1 /usr/local/share/perl/5.22.1 /usr/lib/x86_64-linux-gnu/perl5/5.22 /usr/share/perl5 /usr/lib/x86_64-linux-gnu/perl/5.22 /usr/share/perl/5.22 /usr/local/lib/site_perl /usr/lib/x86_64-linux-gnu/perl-base) at /usr/share/perl5/Debconf/FrontEnd/Readline.pm line 7.)
debconf: falling back to frontend: Teletype
setting up mysql-common (5.7.33-0ubuntu0.16.04.1) ...
update-alternatives: using /etc/mysql/my.cnf.fallback to provide /etc/mysql/my.cnf (my.cnf) in auto mode
setting up libmysqlclient20:amd64 (5.7.33-0ubuntu0.16.04.1) ...
setting up sysbench (0.4.12-1.1ubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu11.3) ...
root@20ed21eda30d:/# sysbench --version
sysbench 0.4.12
root@20ed21eda30d:/#
```

6. Now you can write the bash scripts on nano.
7. After running the scripts with a particular resource then stop the container and then run it again with different resources.

## Experimentation:

We'll start our experimentation on the virtual machine by examining four distinct CPU and RAM configurations. These settings will be initially applied to QEMU using the raw and qcow2 disk images. Next, the Docker run settings will be the same.

As part of this experiment, we will consider four configurations:

- 6 core and 3 GB memory allocation
- 8 core and 4 GB memory allocation
- 2 core and 2 GB memory allocation
- 3 core and 3 GB memory allocation

To complete this experiment successfully we will do three types of testing:

- CPU Testing: To assess CPU performance between QEMU and Docker, we will utilize the following two test scenarios. The sysbench tool and the test cases given below will be used in our testing.
  - **sysbench --test=cpu --cpu-max-prime=20000 run**
  - **sysbench --test=cpu --num-threads=4 --cpu-max-prime=10000 run**

- File I/O Testing: We will use random read/write (rndrw) for File I/O testing. Additionally, we will use the following Sysbench commands and alter the settings for various configurations in order to test.

- **sysbench --test=fileio --file-total-size=250M --file-test-mode=seqwr prepare**  
**sysbench --test=fileio --file-total-size=250M --file-test-mode=seqwr run**  
**sysbench --test=fileio --file-total-size=250M cleanup**

- **sysbench --test=fileio --file-total-size=1G --file-test-mode=rndrd prepare**  
**sysbench --test=fileio --file-total-size=1G --file-test-mode=rndrd run**  
**sysbench --test=fileio --file-total-size=1G cleanup**

- Memory testing: We will use random access (seq) and sequential access (rnd) for memory testing. We will also use the following Sysbench commands for testing, altering the settings for various configurations.

- **sysbench --test=memory --memory-block-size=1K --memory-total-size=100G --memory-access-mode=seq run**

- **sysbench --test=memory --memory-block-size=1K --memory-total-size=100G --memory-access-mode=rnd run**

## **1. Configuration: 2GB RAM & 2 Core**

**QEMU- Raw disk image:**

**CPU Testing:**

Result for **CPU Testing** where Max-Prime = 20000 - test case 1

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 17.9104s
total number of events: 10000
total time taken by event execution: 17.8771
per-request statistics:
  min: 1.39ms
  avg: 1.79ms
  max: 19.73ms
  approx. 95 percentile: 2.12ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 17.8771/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 1.79 ms     | 1.88 ms     | 1.95 ms     | 1.92 ms     | 1.91 ms     |
| Max. time taken                      | 19.73 ms    | 16.24 ms    | 21.10 ms    | 34.42 ms    | 16.68 ms    |
| Min. time taken                      | 1.39 ms     | 1.44 ms     | 1.45 ms     | 1.47 ms     | 1.49 ms     |
| Total time taken for event execution | 17.8771     | 18.7636     | 19.4575     | 19.1727     | 19.1466     |

Result for **CPU Testing** where max-Prime =10000 – test case 2

```
QEMU - Press Ctrl+Alt+G to release grab
Machine: View
Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 19.2029s
total number of events: 10000
total time taken by event execution: 19.1727
per-request statistics:
  min: 1.47ms
  avg: 1.92ms
  max: 34.42ms
  approx. 95 percentile: 2.56ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 19.1727/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 1.92 ms     | 2.01 ms     | 2.20 ms     | 2.21 ms     | 2.17 ms     |
| Max. time taken                      | 63.20 ms    | 46.57 ms    | 37.04 ms    | 35.90 ms    | 34.58 ms    |
| Min. time taken                      | 0.66 ms     | 0.81 ms     | 0.81 ms     | 0.85 ms     | 0.83 ms     |
| Total time taken for event execution | 19.1767     | 20.0672     | 19.4575     | 22.0601     | 21.7440     |

### File I/O Testing:

## QEMU Result for **File I/O Testing** for 2GB RAM and 2 Core for Sequential Write

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (102.95Mb/sec)
6588.88 Requests/sec executed

Test execution summary:
total time: 2.4283s
total number of events: 16000
total time taken by event execution: 1.3533
per-request statistics:
  min: 0.05ms
  avg: 0.08ms
  max: 30.75ms
  approx. 95 percentile: 0.16ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 1.3533/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (97.165Mb/sec)
6218.57 Requests/sec executed

Test execution summary:
total time: 2.5729s
total number of events: 16000
total time taken by event execution: 1.2838
per-request statistics:
  min: 0.05ms
  avg: 0.08ms
  max: 5.23ms
  approx. 95 percentile: 0.16ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 1.2838/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
```

## Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.07 ms     | 0.08 ms     | 0.05 ms     | 0.09 ms     | 0.07 ms     |
| Max. time taken                      | 5.27 ms     | 5.38 ms     | 5.23 ms     | 5.28 ms     | 4.26 ms     |
| Min. time taken                      | 0.03 ms     | 0.05 ms     | 0.07 ms     | 0.08 ms     | 0.04 ms     |
| Total time taken for event execution | 1.1058      | 1.3533      | 1.2838      | 1.4032      | 1.1292      |

QEMU Result for **File I/O Testing** for 2GB RAM and 2 Core for Random reads

```

QEMU - Press Ctrl+Alt+G to release grab
Machine View
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (752.36Mb/sec)
48150.87 Requests/sec executed

Test execution summary:
  total time: 0.2077s
  total number of events: 10000
  total time taken by event execution: 0.1868
  per-request statistics:
    min: 0.01ms
    avg: 0.02ms
    max: 3.67ms
    approx. 95 percentile: 0.02ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.1868/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:

```

```

QEMU - Press Ctrl+Alt+G to release grab
Machine View
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (781.67Mb/sec)
50026.61 Requests/sec executed

Test execution summary:
  total time: 0.1999s
  total number of events: 10000
  total time taken by event execution: 0.1781
  per-request statistics:
    min: 0.01ms
    avg: 0.02ms
    max: 0.84ms
    approx. 95 percentile: 0.02ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.1781/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:

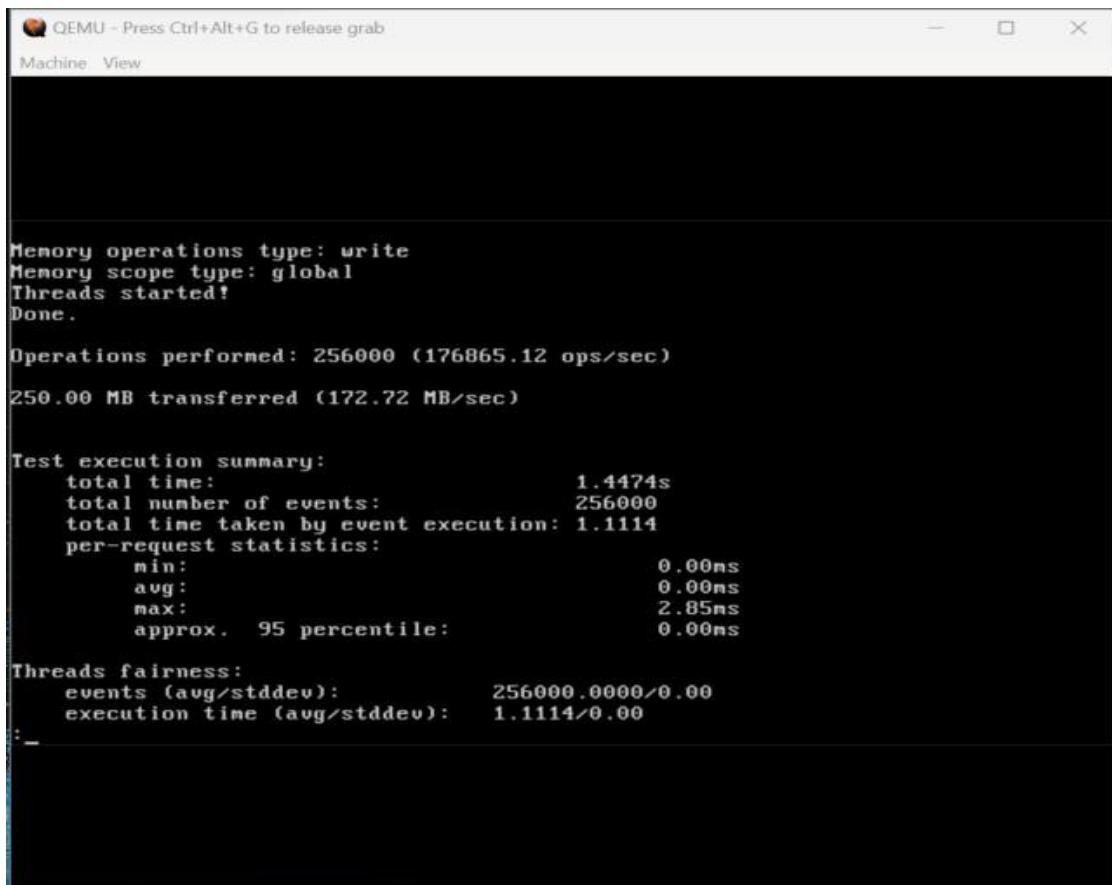
```

**Test Execution Summary:**

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     |
| Max. time taken                      | 3.47 ms     | 3.67 ms     | 3.88 ms     | 2.86 ms     | 2.84 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 0.1770      | 0.1868      | 0.1781      | 0.1876      | 0.1835      |

### Memory Testing:

QEMU Result for **Memory Testing** for 2GB RAM and 2 Core for Sequential Memory Access – Total memory size = 250 MB



```

QEMU - Press Ctrl+Alt+G to release grab
Machine View

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (176865.12 ops/sec)
250.00 MB transferred (172.72 MB/sec)

Test execution summary:
  total time: 1.4474s
  total number of events: 256000
  total time taken by event execution: 1.1114
  per-request statistics:
    min: 0.00ns
    avg: 0.00ns
    max: 2.85ns
    approx. 95 percentile: 0.00ns

Threads fairness:
  events (avg/stddev): 256000.0000/0.00
  execution time (avg/stddev): 1.1114/0.00
: -

```

### **Test Execution Summary:**

|                 | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|-----------------|-------------|-------------|-------------|-------------|-------------|
| Average         | 0.01 ms     | 0.01 ms     | 0.00 ms     | 0.01 ms     | 0.02 ms     |
| Max. time taken | 5.41 ms     | 5.55 ms     | 2.85 ms     | 3.45 ms     | 3.66 ms     |

|                                      |         |         |         |         |         |
|--------------------------------------|---------|---------|---------|---------|---------|
| Min. time taken                      | 0.01 ms | 0.01 ms | 0.00 ms | 0.01 ms | 0.01 ms |
| Total time taken for event execution | 1.0000  | 0.1868  | 0.1781  | 0.1876  | 0.1835  |

QEMU Result for **Memory Testing** for 2GB RAM and 2 Core for Random read – Total memory size = 250MB

```

QEMU - Press Ctrl+Alt+G to release grab
Machine View

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (183410.00 ops/sec)
250.00 MB transferred (179.11 MB/sec)

Test execution summary:
total time: 1.3958s
total number of events: 256000
total time taken by event execution: 1.0451
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 2.92ms
  approx. 95 percentile: 0.00ms

Threads fairness:
events (avg/stddev): 256000.0000/0.00
execution time (avg/stddev): 1.0451/0.00

```

### Test Execution Summary:

|                 | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|-----------------|-------------|-------------|-------------|-------------|-------------|
| Average         | 0.01 ms     | 0.01 ms     | 0.00 ms     | 0.00 ms     | 0.02 ms     |
| Max. time taken | 2.56 ms     | 2.21 ms     | 1.92 ms     | 2.85 ms     | 2.77 ms     |
| Min. time taken | 0.01 ms     | 0.01 ms     | 0.02 ms     | 0.00 ms     | 0.01 ms     |



|                                      |        |        |        |        |        |
|--------------------------------------|--------|--------|--------|--------|--------|
| Total time taken for event execution | 0.9359 | 1.0404 | 0.9652 | 1.1114 | 1.0633 |
|--------------------------------------|--------|--------|--------|--------|--------|

### QEMU- qcow2 disk image:

### CPU Testing:

Result for QEMU qcow2 for **CPU Testing** where Max-Prime = 20000 - test case 1

```

QEMU - Press Ctrl+Alt+G to release grab
Machine View

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 35.5088s
total number of events: 10000
total time taken by event execution: 35.4315
per-request statistics:
  min: 2.50ms
  avg: 3.54ms
  max: 22.05ms
  approx. 95 percentile: 5.02ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 35.4315/0.00

Iteration 2 of cpu test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!

```

### **Test Execution Summary:**

|                 | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|-----------------|-------------|-------------|-------------|-------------|-------------|
| Average         | 3.54 ms     | 3.68 ms     | 3.74 ms     | 2.89 ms     | 3.67 ms     |
| Max. time taken | 22.05 ms    | 22.25 ms    | 21.92 ms    | 22.06 ms    | 22.77 ms    |
| Min. time taken | 2.50 ms     | 2.67 ms     | 2.87 ms     | 2.53 ms     | 2.51 ms     |

|                                      |         |         |         |         |         |
|--------------------------------------|---------|---------|---------|---------|---------|
| Total time taken for event execution | 35.4315 | 36.3325 | 34.2253 | 35.4521 | 36.2885 |
|--------------------------------------|---------|---------|---------|---------|---------|

Result for QEMU qcow2 for **CPU Testing** where max-Prime =10000 – test case 2

The screenshot shows a QEMU terminal window with the following text:

```

QEMU - Press Ctrl+Alt+G to release grab
Machine View

Threads fairness:
  events (avg/stddev):       2500.0000/24.05
  execution time (avg/stddev): 8.0063/0.01

Iteration 5 of CPU test with multiple threads
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
  total time:                7.8833s
  total number of events:    10000
  total time taken by event execution: 31.1890
  per-request statistics:
    min:                     1.05ns
    avg:                     3.12ns
    max:                     30.64ns
    approx. 95 percentile:   10.48ns

Threads fairness:
  events (avg/stddev):       2500.0000/15.38
  execution time (avg/stddev): 7.7972/0.01

All CPU tests completed.

```

### Test Execution Summary:

|                 | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|-----------------|-------------|-------------|-------------|-------------|-------------|
| Average         | 3.12 ms     | 3.15 ms     | 3.74 ms     | 3.89 ms     | 3.67 ms     |
| Max. time taken | 30.64 ms    | 31.01 ms    | 30.85 ms    | 30.06 ms    | 30.77 ms    |
| Min. time taken | 1.05 ms     | 1.12 ms     | 1.18 ms     | 1.53 ms     | 1.51 ms     |

|                                      |         |         |         |         |         |
|--------------------------------------|---------|---------|---------|---------|---------|
| Total time taken for event execution | 38.1890 | 37.3325 | 38.2253 | 38.4521 | 38.2885 |
|--------------------------------------|---------|---------|---------|---------|---------|

### File I/O Testing:

QEMU qcow2 Result for **File I/O Testing** for 2GB RAM and 2 Core for Sequential Write

```

QEMU - Press Ctrl+Alt+G to release grab
Machine View
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 65536 Write, 128 Other = 65664 Total
Read 0b Written 1Gb Total transferred 1Gb (99.613Mb/sec)
6375.25 Requests/sec executed

Test execution summary:
total time: 10.2798s
total number of events: 65536
total time taken by event execution: 6.0964
per-request statistics:
  min: 0.06ms
  avg: 0.09ms
  max: 6.86ms
  approx. 95 percentile: 0.16ms

Threads fairness:
  events (avg/stddev): 65536.0000/0.00
  execution time (avg/stddev): 6.0964/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 2
:

```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark
128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 65536 Write, 128 Other = 65664 Total
Read 0b Written 1Gb Total transferred 1Gb (77.007Mb/sec)
4928.43 Requests/sec executed

Test execution summary:
total time: 13.2975s
total number of events: 65536
total time taken by event execution: 7.6571
per-request statistics:
min: 0.06ms
avg: 0.12ms
max: 200.25ms
approx. 95 percentile: 0.18ms
:
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Threads fairness:
events (avg/stddev): 65536.0000/0.00
execution time (avg/stddev): 7.6571/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark
128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 65536 Write, 128 Other = 65664 Total
Read 0b Written 1Gb Total transferred 1Gb (61.677Mb/sec)
3947.32 Requests/sec executed

Test execution summary:
total time: 16.6027s
:
```

QEMU - Press Ctrl+Alt+G to release grab

Machine View

```
Test execution summary:
  total time: 16.6027s
  total number of events: 65536
  total time taken by event execution: 9.2447
  per-request statistics:
    min: 0.06ms
    avg: 0.14ms
    max: 1399.65ms
    approx. 95 percentile: 0.18ms

Threads fairness:
  events (avg/stddev): 65536.0000/0.00
  execution time (avg/stddev): 9.2447/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 4
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
-
```

QEMU - Press Ctrl+Alt+G to release grab

Machine View

```
Operations performed: 0 Read, 65536 Write, 128 Other = 65664 Total
Read 0b Written 1Gb Total transferred 1Gb (77.298Mb/sec)
4947.04 Requests/sec executed

Test execution summary:
  total time: 13.2475s
  total number of events: 65536
  total time taken by event execution: 7.2135
  per-request statistics:
    min: 0.06ms
    avg: 0.11ms
    max: 110.97ms
    approx. 95 percentile: 0.18ms

Threads fairness:
  events (avg/stddev): 65536.0000/0.00
  execution time (avg/stddev): 7.2135/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 5
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed:  0 Read, 65536 Write, 128 Other = 65664 Total
Read 0b Written 1Gb Total transferred 1Gb (75.355Mb/sec)
4822.71 Requests/sec executed

Test execution summary:
  total time:                13.5890s
  total number of events:    65536
  total time taken by event execution: 7.6120
  per-request statistics:
    min:                      0.06ms
    avg:                      0.12ms
    max:                      119.94ms
    approx. 95 percentile:    0.19ms

Threads fairness:
  events (avg/stddev):       65536.0000/0.00
  execution time (avg/stddev): 7.6120/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark
Removing test files...

Running Second File I/O Test: Random Read
Iteration 1
:
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 2.12 ms     | 2.15 ms     | 2.75 ms     | 2.65 ms     | 2.37 ms     |
| Max. time taken                      | 3.25 ms     | 3.18 ms     | 3.66 ms     | 3.42 ms     | 3.51 ms     |
| Min. time taken                      | 1.02ms      | 1.25 ms     | 1.32 ms     | 1.25 ms     | 1.38 ms     |
| Total time taken for event execution | 1.6544      | 1.8524      | 1.3652      | 1.8854      | 1.8527      |

QEMU qcow2 Result for **File I/O Testing** for 2GB RAM and 2 Core for Random read and write.

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark
128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (668.23Mb/sec)
42766.95 Requests/sec executed

Test execution summary:
total time: 0.2338s
total number of events: 10000
total time taken by event execution: 0.2097
per-request statistics:
min: 0.01ms
avg: 0.02ms
max: 3.87ms
approx. 95 percentile: 0.03ms
:
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Threads fairness:
events (avg/stddev): 10000.0000/0.00
execution time (avg/stddev): 0.2097/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark
Removing test files...

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark
128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (665.34Mb/sec)
42581.79 Requests/sec executed

Test execution summary:
:
```

Machine View

```
Test execution summary:
  total time: 0.2348s
  total number of events: 10000
  total time taken by event execution: 0.2106
  per-request statistics:
    min: 0.01ms
    avg: 0.02ms
    max: 3.80ms
    approx. 95 percentile: 0.03ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.2106/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
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.
:~
```

Machine View

```
Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (619.81Mb/sec)
39667.57 Requests/sec executed

Test execution summary:
  total time: 0.2521s
  total number of events: 10000
  total time taken by event execution: 0.2241
  per-request statistics:
    min: 0.01ms
    avg: 0.02ms
    max: 3.23ms
    approx. 95 percentile: 0.03ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.2241/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 4
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
:
```



```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (465.37Mb/sec)
29783.63 Requests/sec executed

Test execution summary:
    total time: 0.3358s
    total number of events: 10000
    total time taken by event execution: 0.3008
    per-request statistics:
        min: 0.01ms
        avg: 0.03ms
        max: 6.16ms
        approx. 95 percentile: 0.04ms

Threads fairness:
    events (avg/stddev): 10000.0000/0.00
    execution time (avg/stddev): 0.3008/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 5
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
:
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (705.39Mb/sec)
45144.95 Requests/sec executed

Test execution summary:
    total time: 0.2215s
    total number of events: 10000
    total time taken by event execution: 0.1997
    per-request statistics:
        min: 0.01ms
        avg: 0.02ms
        max: 4.21ms
        approx. 95 percentile: 0.03ms

Threads fairness:
    events (avg/stddev): 10000.0000/0.00
    execution time (avg/stddev): 0.1997/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 2.25 ms     | 2.65 ms     | 2.45 ms     | 2.65 ms     | 2.74 ms     |
| Max. time taken                            | 3.33 ms     | 3.52 ms     | 3.85 ms     | 3.32 ms     | 3.45 ms     |
| Min. time taken                            | 1.12ms      | 1.88 ms     | 1.36 ms     | 1.65 ms     | 1.65 ms     |
| Total time taken<br>for event<br>execution | 1.8522      | 1.4528      | 1.8854      | 1.4585      | 1.6522      |

### Memory Testing:

QEMU qcow2 Result for **Memory Testing** for 2GB RAM and 2 Core for Sequential Memory Access – Total memory size = 250 MB

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Running First Memory Test: Sequential Access
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (123695.23 ops/sec)
200.00 MB transferred (120.80 MB/sec)

Test execution summary:
  total time:                1.6557s
  total number of events:    204800
  total time taken by event execution: 1.2604
  per-request statistics:
    min:                     0.00ms
    avg:                     0.01ms
    max:                     4.68ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       204800.0000/0.00
  execution time (avg/stddev): 1.2604/0.00
:_
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (123593.29 ops/sec)
200.00 MB transferred (120.70 MB/sec)

Test execution summary:
  total time: 1.6570s
  total number of events: 204800
  total time taken by event execution: 1.2693
  per-request statistics:
    min: 0.00ms
    avg: 0.01ms
    max: 3.86ms
    approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 1.2693/0.00
:
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (143800.06 ops/sec)
200.00 MB transferred (140.43 MB/sec)

Test execution summary:
  total time: 1.4242s
  total number of events: 204800
  total time taken by event execution: 1.0910
  per-request statistics:
    min: 0.00ms
    avg: 0.01ms
    max: 3.86ms
    approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 1.0910/0.00
:
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 4
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (120521.32 ops/sec)

200.00 MB transferred (117.70 MB/sec)

Test execution summary:
total time: 1.6993s
total number of events: 204800
total time taken by event execution: 1.2973
per-request statistics:
  min: 0.00ms
  avg: 0.01ms
  max: 4.33ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 1.2973/0.00
:
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 5
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (122703.87 ops/sec)

200.00 MB transferred (119.83 MB/sec)

Test execution summary:
total time: 1.6691s
total number of events: 204800
total time taken by event execution: 1.2848
per-request statistics:
  min: 0.00ms
  avg: 0.01ms
  max: 6.85ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 1.2848/0.00
:_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 4.68 ms     | 3.86 ms     | 3.86 ms     | 4.33 ms     | 6.85 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 1.2604      | 1.2693      | 1.0910      | 1.2973      | 1.2848      |

QEMU qow2 Result for **Memory Testing** for 2GB RAM and 2 Core for Random read  
– Total memory size = 250MB

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Running Second memory Test: Random Access
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (114884.66 ops/sec)
200.00 MB transferred (112.19 MB/sec)

Test execution summary:
  total time:                1.7827s
  total number of events:     204800
  total time taken by event execution: 1.3190
  per-request statistics:
    min:                     0.00ms
    avg:                     0.01ms
    max:                     4.23ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       204800.0000/0.00
  execution time (avg/stddev): 1.3190/0.00
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (113814.29 ops/sec)
200.00 MB transferred (111.15 MB/sec)

Test execution summary:
total time: 1.7994s
total number of events: 204800
total time taken by event execution: 1.3655
per-request statistics:
  min: 0.00ms
  avg: 0.01ms
  max: 4.50ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 1.3655/0.00
```

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (129007.61 ops/sec)
200.00 MB transferred (125.98 MB/sec)

Test execution summary:
total time: 1.5875s
total number of events: 204800
total time taken by event execution: 1.1866
per-request statistics:
  min: 0.00ms
  avg: 0.01ms
  max: 5.03ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 1.1866/0.00
:_
```

Machine View

Iteration 4  
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:  
Number of threads: 1

Doing memory operations speed test  
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write  
Memory scope type: global  
Threads started!  
Done.

Operations performed: 204800 (149925.55 ops/sec)

200.00 MB transferred (146.41 MB/sec)

Test execution summary:

|                                      |         |
|--------------------------------------|---------|
| total time:                          | 1.3660s |
| total number of events:              | 204800  |
| total time taken by event execution: | 1.0301  |
| per-request statistics:              |         |
| min:                                 | 0.00ms  |
| avg:                                 | 0.01ms  |
| max:                                 | 3.86ms  |
| approx. 95 percentile:               | 0.00ms  |

Threads fairness:

|                              |                  |
|------------------------------|------------------|
| events (avg/stddev):         | 204800.0000/0.00 |
| execution time (avg/stddev): | 1.0301/0.00      |

:

Machine View

Iteration 5  
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:  
Number of threads: 1

Doing memory operations speed test  
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write  
Memory scope type: global  
Threads started!  
Done.

Operations performed: 204800 (131398.43 ops/sec)

200.00 MB transferred (128.32 MB/sec)

Test execution summary:

|                                      |         |
|--------------------------------------|---------|
| total time:                          | 1.5586s |
| total number of events:              | 204800  |
| total time taken by event execution: | 1.1760  |
| per-request statistics:              |         |
| min:                                 | 0.00ms  |
| avg:                                 | 0.01ms  |
| max:                                 | 4.01ms  |
| approx. 95 percentile:               | 0.00ms  |

Threads fairness:

|                              |                  |
|------------------------------|------------------|
| events (avg/stddev):         | 204800.0000/0.00 |
| execution time (avg/stddev): | 1.1760/0.00      |

:

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 4.23 ms     | 4.50 ms     | 5.03 ms     | 3.86 ms     | 4.01 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 1.3190      | 1.3655      | 1.1866      | 1.0301      | 1.1760      |

### Docker Results for 2 GB 2 Core:

#### CPU Testing:

Results for Docker based **CPU Testing** where Max-Prime = 20000 - test case 1

```
root@7d501109e147:/# ./cpu_bash_script.sh | less
bash: less: command not found
root@7d501109e147:/# ./cpu_bash_script.sh
Running First CPU Test: High Prime Number Calculation
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 7.0010s
total number of events: 10000
total time taken by event execution: 6.9997
per-request statistics:
  min: 0.63ms
  avg: 0.70ms
  max: 2.71ms
  approx. 95 percentile: 0.81ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 6.9997/0.00
```



```

Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
  total time:                7.0577s
  total number of events:    10000
  total time taken by event execution: 7.0564
  per-request statistics:
    min:                     0.63ms
    avg:                     0.71ms
    max:                     3.32ms
    approx. 95 percentile:   0.80ms

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 7.0564/0.00

```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.70 ms     | 0.71 ms     | 0.71 ms     | 0.75 ms     | 0.76 ms     |
| Max. time taken                            | 2.72 ms     | 3.21 ms     | 3.32 ms     | 3.86 ms     | 3.01 ms     |
| Min. time taken                            | 0.63 ms     | 0.65 ms     | 0.63 ms     | 0.63 ms     | 0.63 ms     |
| Total time taken<br>for event<br>execution | 6.9997      | 7.2586      | 7.0564      | 7.4458      | 7.4589      |

Results for Docker based **CPU Testing** where Max-Prime = 10000 - test case 2

Iteration 2  
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:  
Number of threads: 4

Doing CPU performance benchmark

Threads started!  
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:

|                                      |         |
|--------------------------------------|---------|
| total time:                          | 1.5786s |
| total number of events:              | 10000   |
| total time taken by event execution: | 6.3099  |
| per-request statistics:              |         |
| min:                                 | 0.27ms  |
| avg:                                 | 0.63ms  |
| max:                                 | 56.91ms |
| approx. 95 percentile:               | 0.54ms  |

Threads fairness:

|                              |                 |
|------------------------------|-----------------|
| events (avg/stddev):         | 2500.0000/10.56 |
| execution time (avg/stddev): | 1.5775/0.00     |

Iteration 4  
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:  
Number of threads: 4

Doing CPU performance benchmark

Threads started!  
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:

|                                      |         |
|--------------------------------------|---------|
| total time:                          | 1.5805s |
| total number of events:              | 10000   |
| total time taken by event execution: | 6.3191  |
| per-request statistics:              |         |
| min:                                 | 0.24ms  |
| avg:                                 | 0.63ms  |
| max:                                 | 51.65ms |
| approx. 95 percentile:               | 0.55ms  |

Threads fairness:

|                              |                 |
|------------------------------|-----------------|
| events (avg/stddev):         | 2500.0000/26.14 |
| execution time (avg/stddev): | 1.5798/0.00     |

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.63 ms     | 0.63 ms     | 0.63 ms     | 0.63 ms     | 0.63 ms     |
| Max. time taken                      | 56.77 ms    | 56.91 ms    | 56.32 ms    | 51.65 ms    | 57.01 ms    |
| Min. time taken                      | 0.27 ms     | 0.27 ms     | 0.28 ms     | 0.24 ms     | 0.26 ms     |
| Total time taken for event execution | 6.3099      | 6.4587      | 6.1285      | 6.3191      | 6.6521      |

### File I/O Testing:

Docker Result for **File I/O Testing** for 2GB RAM and 2 Core for Sequential Write

```
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (926.81Mb/sec)
59315.56 Requests/sec executed

Test execution summary:
  total time:                                0.2697s
  total number of events:                    16000
  total time taken by event execution: 0.0866
  per-request statistics:
    min:                                     0.00ms
    avg:                                     0.01ms
    max:                                     0.27ms
    approx. 95 percentile:                  0.01ms

Threads fairness:
  events (avg/stddev):       16000.0000/0.00
  execution time (avg/stddev): 0.0866/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
```

```

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (893.15Mb/sec)
57161.56 Requests/sec executed

Test execution summary:
    total time:                0.2799s
    total number of events:    16000
    total time taken by event execution: 0.0934
    per-request statistics:
        min:                    0.00ms
        avg:                     0.01ms
        max:                     0.47ms
        approx. 95 percentile:   0.01ms

Threads fairness:
    events (avg/stddev):       16000.0000/0.00
    execution time (avg/stddev): 0.0934/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                            | 0.27 ms     | 0.25 ms     | 0.32 ms     | 0.26 ms     | 0.47 ms     |
| Min. time taken                            | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken<br>for event<br>execution | 0.0866      | 0.1244      | 0.9822      | 0.5288      | 0.0934      |

## Docker Result for **File I/O Testing** for 2GB RAM and 2 Core for Random Read

```
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (5.9137Gb/sec)
387557.35 Requests/sec executed

Test execution summary:
total time: 0.0258s
total number of events: 10000
total time taken by event execution: 0.0246
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 1.04ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.0246/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
```

```
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (6.2248Gb/sec)
407949.22 Requests/sec executed

Test execution summary:
total time: 0.0245s
total number of events: 10000
total time taken by event execution: 0.0230
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 0.44ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.0230/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Max. time taken                      | 0.77 ms     | 1.04 ms     | 0.52 ms     | 0.44 ms     | 0.46 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0158      | 0.0246      | 0.0668      | 0.0230      | 0.0452      |

### Memory Testing:

Docker results for **Memory Testing** for 2GB RAM and 2 Core for Sequential Memory Access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (5268661.94 ops/sec)
250.00 MB transferred (5145.18 MB/sec)

Test execution summary:
total time: 0.0486s
total number of events: 256000
total time taken by event execution: 0.0392
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 0.28ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 256000.0000/0.00
  execution time (avg/stddev): 0.0392/0.00
```

```

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (5135809.25 ops/sec)

250.00 MB transferred (5015.44 MB/sec)

Test execution summary:
  total time:                                0.0498s
  total number of events:                    256000
  total time taken by event execution: 0.0400
  per-request statistics:
    min:                                    0.00ms
    avg:                                    0.00ms
    max:                                    0.18ms
    approx. 95 percentile:                  0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0400/0.00

```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Max. time taken                            | 0.25 ms     | 0.27 ms     | 0.22 ms     | 0.28 ms     | 0.18 ms     |
| Min. time taken                            | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken<br>for event<br>execution | 0.0365      | 0.0238      | 0.0395      | 0.0392      | 0.0400      |

Docker results for **Memory Testing** for 2GB RAM and 2 Core for Random Read –  
Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (6155796.92 ops/sec)

250.00 MB transferred (6011.52 MB/sec)

Test execution summary:
  total time:                0.0416s
  total number of events:    256000
  total time taken by event execution: 0.0324
  per-request statistics:
    min:                     0.00ms
    avg:                     0.00ms
    max:                     0.15ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0324/0.00
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Max. time taken                            | 0.20 ms     | 0.16 ms     | 0.15 ms     | 0.17 ms     | 0.19 ms     |
| Min. time taken                            | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken<br>for event<br>execution | 0.0322      | 0.0323      | 0.0324      | 0.0325      | 0.0326      |

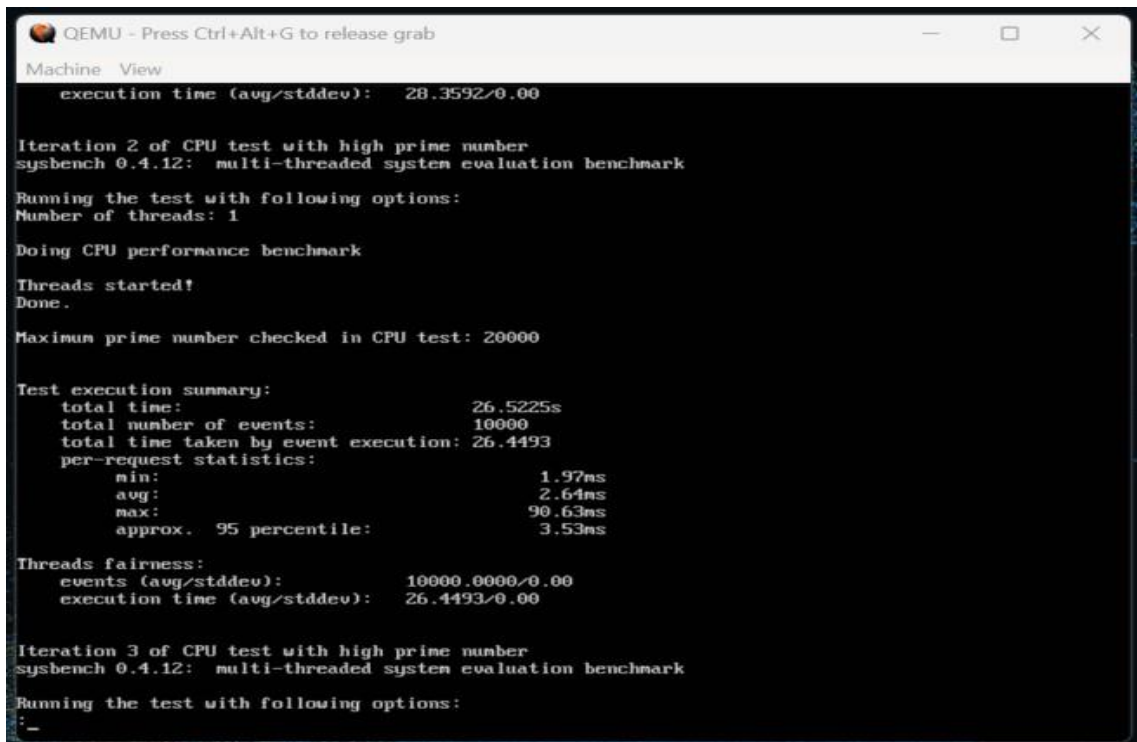


## 2. Configuration: 3GB RAM & 3 Core

### QEMU- Raw disk image:

### CPU Testing:

Result for **CPU Testing** where Max-Prime = 20000 - test case 1



```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
execution time (avg/stddev): 28.3592/0.00

Iteration 2 of CPU test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

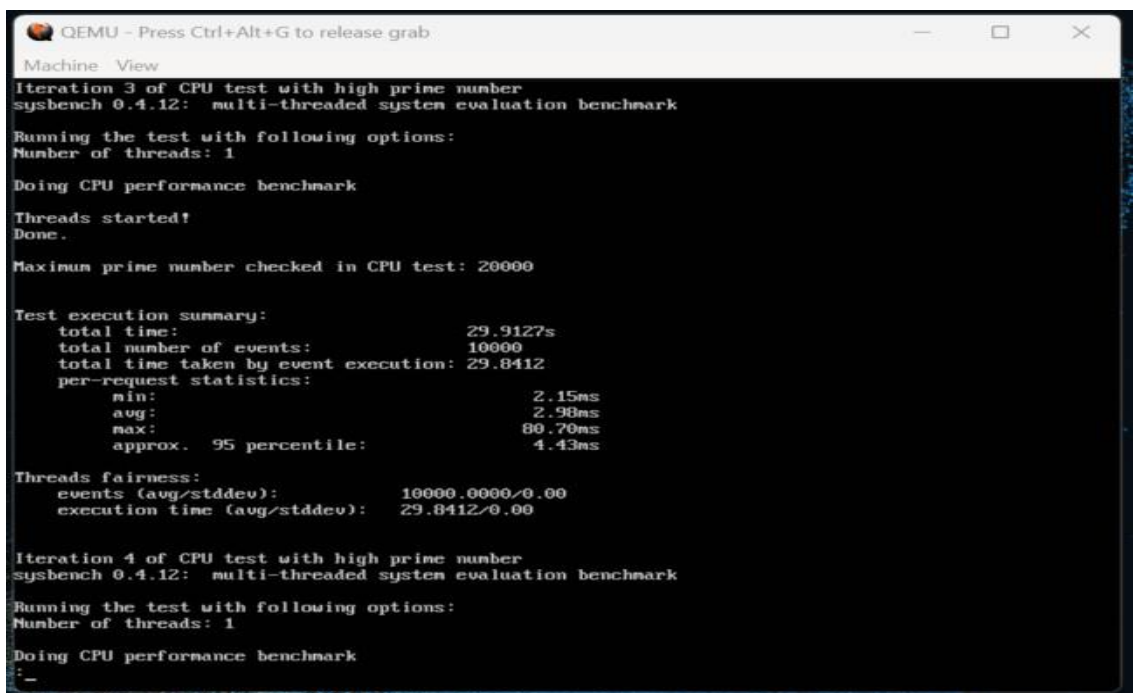
Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 26.5225s
total number of events: 10000
total time taken by event execution: 26.4493
per-request statistics:
  min: 1.97ms
  avg: 2.64ms
  max: 90.63ms
  approx. 95 percentile: 3.53ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 26.4493/0.00

Iteration 3 of CPU test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
: _
```



```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Iteration 3 of CPU test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 29.9127s
total number of events: 10000
total time taken by event execution: 29.8412
per-request statistics:
  min: 2.15ms
  avg: 2.98ms
  max: 80.70ms
  approx. 95 percentile: 4.43ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 29.8412/0.00

Iteration 4 of CPU test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark
: _
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 2.61 ms     | 2.64 ms     | 2.15 ms     | 2.72 ms     | 2.76 ms     |
| Max. time taken                      | 3221 ms     | 90.63 ms    | 80.70 ms    | 73.32 ms    | 71.09 ms    |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 28.3592     | 26.4493     | 29.8412     | 32.3234     | 34.2015     |

Result for **CPU Testing** where Max-Prime = 10000 - test case 2

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Running Second CPU Test:Multiple Threads
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
total time: 8.3261s
total number of events: 10000
total time taken by event execution: 32.6264
per-request statistics:
  min: 1.02ms
  avg: 3.26ms
  max: 70.70ms
  approx. 95 percentile: 11.76ms

Threads fairness:
  events (avg/stddev): 2500.0000/27.12
  execution time (avg/stddev): 8.1566/0.03

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4
:
_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 3.21 ms     | 3.96 ms     | 3.65 ms     | 3.04 ms     | 2.92 ms     |
| Max. time taken                      | 70.76 ms    | 136.95 ms   | 46.87 ms    | 97.29 ms    | 61.26 ms    |
| Min. time taken                      | 1.82 ms     | 1.12 ms     | 1.10 ms     | 1.82 ms     | 0.98 ms     |
| Total time taken for event execution | 32.6254     | 39.5958     | 35.5314     | 30.4200     | 29.1859     |

### File I/O Testing:

QEMU raw Result for **File I/O Testing** for 3 GB RAM and 3 Core for Sequential Write

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (60.416Mb/sec)
3866.61 Requests/sec executed

Test execution summary:
total time: 4.1300s
total number of events: 16000
total time taken by event execution: 2.2038
per-request statistics:
  nin: 0.00ms
  avg: 0.14ms
  max: 7.54ms
  approx. 95 percentile: 0.29ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 2.2038/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 3.21 ms     | 3.96 ms     | 3.65 ms     | 3.04 ms     | 2.92 ms     |
| Max. time taken                            | 70.76 ms    | 136.95 ms   | 46.87 ms    | 97.29 ms    | 61.26 ms    |
| Min. time taken                            | 1.82 ms     | 1.12 ms     | 1.10 ms     | 1.82 ms     | 0.98 ms     |
| Total time taken<br>for event<br>execution | 32.6254     | 39.5958     | 35.5314     | 30.4200     | 29.1859     |

QEMU raw Result for **File I/O Testing** for 3 GB RAM and 3 Core for Random reads

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Number of threads: 1
Extra file open flags: 0
128 files, 2.3438Mb each
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (598.91Mb/sec)
38330.07 Requests/sec executed

Test execution summary:
total time: 0.2609s
total number of events: 10000
total time taken by event execution: 0.2235
per-request statistics:
  min: 0.01ms
  avg: 0.02ms
  max: 1.51ms
  approx. 95 percentile: 0.02ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.2235/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

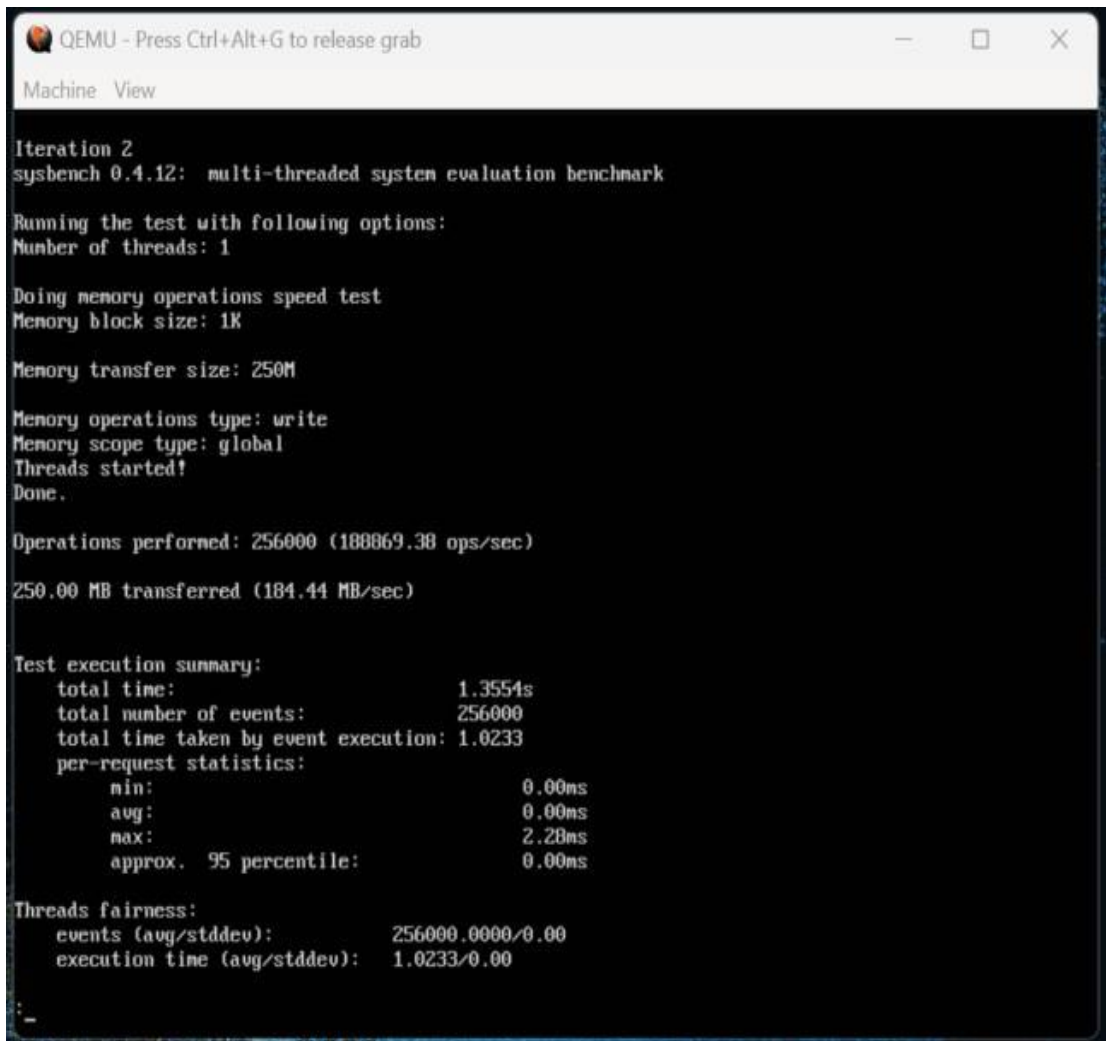
Removing test files...
:_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     |
| Max. time taken                      | 1.33 ms     | 11.94 ms    | 15.45 ms    | 11.13 ms    | 1.51 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 0.3400      | 0.2720      | 0.2306      | 0.2323      | 0.2235      |

### Memory Testing:

QEMU raw results for **Memory Testing** for 2GB RAM and 2 Core for Sequential Memory Access – Total memory size = 250 MB



```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (188869.38 ops/sec)
250.00 MB transferred (184.44 MB/sec)

Test execution summary:
  total time:                1.3554s
  total number of events:    256000
  total time taken by event execution: 1.0233
  per-request statistics:
    min:                     0.00ms
    avg:                     0.00ms
    max:                     2.28ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 1.0233/0.00
:
_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Max. time taken                      | 5.72 ms     | 2.28 ms     | 2.45 ms     | 3.10 ms     | 4.09 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 1.1330      | 1.0233      | 0.9632      | 1.6297      | 0.9770      |

QEMU raw results for **Memory Testing** for 2GB RAM and 2 Core for Random Memory Access – Total memory size = 250 MB

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Running Second Memory Test: Random Access
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (193851.03 ops/sec)
250.00 MB transferred (189.31 MB/sec)

Test execution summary:
total time: 1.3206s
total number of events: 256000
total time taken by event execution: 0.9919
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 3.38ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 256000.0000/0.00
  execution time (avg/stddev): 0.9919/0.00
_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Max. time taken                      | 3.38 ms     | 2.67 ms     | 20.64 ms    | 2.85 ms     | 4.56 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.9919      | 1.1701      | 1.3049      | 1.1829      | 1.0373      |

### QEMU- qcow2 disk image:

### CPU Testing:

Result for **CPU Testing** where Max-Prime = 20000 - test case 1

```
test execution summary:
  total time:                    5.7303s
  total number of events:        10000
  total time taken by event execution: 5.6987
  per-request statistics:
    min:                         0.37ns
    avg:                         0.57ns
    max:                         6.10ns
    approx. 95 percentile:       1.03ns

threads fairness:
  events (avg/stddev):           10000.0000/0.00
  execution time (avg/stddev):   5.6987/0.00
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.57 ms     | 1.80 ms     | 1.83 ms     | 1.86 ms     | 1.39 ms     |
| Max. time taken                            | 6.10 ms     | 10.39 ms    | 7.75 ms     | 14.12 ms    | 16.33 ms    |
| Min. time taken                            | 0.37 ms     | 1.39 ms     | 1.41 ms     | 1.38 ms     | 1.39 ms     |
| Total time taken<br>for event<br>execution | 5.6987      | 17.9964     | 18.2734     | 18.5544     | 19.5683     |

Result for **CPU Testing** where Max-Prime = 10000 - test case 2

Maximum prime number checked in CPU test: 4000

#### Test execution summary:

total time: 1.6563s  
total number of events: 10000  
total time taken by event execution: 8.1855  
per-request statistics:  
    min: 0.27ns  
    avg: 0.82ns  
    max: 21.43ns  
    approx. 95 percentile: 1.00ns

#### Threads fairness:

events (avg/stddev): 2000.0000/223.82  
execution time (avg/stddev): 1.6371/0.01



### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.82 ms     | 1.96 ms     | 2.00 ms     | 1.69 ms     | 1.75 ms     |
| Max. time taken                      | 21.43 ms    | 59.79 ms    | 48.04 ms    | 49.55 ms    | 42.36 ms    |
| Min. time taken                      | 0.27 ms     | 0.90 ms     | 0.93 ms     | 0.75 ms     | 0.86 ms     |
| Total time taken for event execution | 8.1855      | 19.6328     | 20.8327     | 18.4528     | 19.7562     |

### File I/O Testing:

QEMU qcow2 Result for **File I/O Testing** for 3 GB RAM and 3 Core for Sequential Write

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (124.99Mb/sec)
7999.11 Requests/sec executed

Test execution summary:
total time: 2.0002s
total number of events: 16000
total time taken by event execution: 0.8725
per-request statistics:
  min: 0.03ms
  avg: 0.05ms
  max: 7.92ms
  approx. 95 percentile: 0.08ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 0.8725/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:
```

## Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.06 ms     | 0.05 ms     | 0.05 ms     | 0.05 ms     | 0.06 ms     |
| Max. time taken                            | 7.69 ms     | 7.76 ms     | 7.86 ms     | 7.96 ms     | 8.06 ms     |
| Min. time taken                            | 0.03 ms     | 0.03 ms     | 0.03 ms     | 0.03 ms     | 0.03 ms     |
| Total time taken<br>for event<br>execution | 0.8872      | 0.8461      | 20.8327     | 18.4528     | 19.7562     |

QEMU qcow2 Result for **File I/O Testing** for 3 GB RAM and 3 Core for Random read

```
QEMU - Press Ctrl+Alt+G to release grab

Machine View
Threads fairness:
  events (avg/stddev):      65536.0000/0.00
  execution time (avg/stddev): 8.5475/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 65536 Write, 128 Other = 65664 Total
Read 0b Written 1Gb Total transferred 1Gb (120.95Mb/sec)
7740.96 Requests/sec executed

Test execution summary:
  total time:                8.4661s
  total number of events:    65536
```

```
QEMU - Press Ctrl+Alt+G to release grab

Machine View
Test execution summary:
  total time: 0.3294s
  total number of events: 10000
  total time taken by event execution: 0.2996
  per-request statistics:
    min: 0.01ms
    avg: 0.03ms
    max: 4.09ms
    approx. 95 percentile: 0.04ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.2996/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 8192Kb each, 1024Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 8Mb each
1Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
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.
:
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                            | 3.47 ms     | 3.85 ms     | 3.65 ms     | 3.88 ms     | 3.48 ms     |
| Min. time taken                            | 0.03 ms     | 0.03 ms     | 0.03 ms     | 0.03 ms     | 0.03 ms     |
| Total time taken<br>for event<br>execution | 0.3127      | 0.4566      | 0.8522      | 0.2489      | 0.6654      |

## Memory Testing:

QEMU qcow2 results for **Memory Testing** for 2GB RAM and 2 Core for Sequential Memory Access – Total memory size = 250 MB

```
QEMU - Press Ctrl+Alt+G to release grab
Machine  View
Running First Memory Test: Sequential Access
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (126135.48 ops/sec)
200.00 MB transferred (123.18 MB/sec)

Test execution summary:
  total time:                1.6237s
  total number of events:    204800
  total time taken by event execution: 1.2465
  per-request statistics:
    min:                      0.00ms
    avg:                      0.01ms
    max:                      10.55ms
    approx. 95 percentile:    0.00ms

Threads fairness:
  events (avg/stddev):       204800.0000/0.00
  execution time (avg/stddev): 1.2465/0.00
.
```

## **Test Execution Summary:**

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                            | 10.55 ms    | 10.44 ms    | 10.88 ms    | 10.21 ms    | 10.35 ms    |
| Min. time taken                            | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken<br>for event<br>execution | 1.2645      | 1.5568      | 1.5582      | 1.7458      | 1.6588      |

QEMU qcow2 results for **Memory Testing** for 2GB RAM and 2 Core for Random Memory Access – Total memory size = 250 MB

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Running Second memory Test: Random Access
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 200M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 204800 (165712.22 ops/sec)
200.00 MB transferred (161.83 MB/sec)

Test execution summary:
total time: 1.2359s
total number of events: 204800
total time taken by event execution: 0.9139
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 10.75ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 204800.0000/0.00
  execution time (avg/stddev): 0.9139/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 10.75 ms    | 10.65 ms    | 10.25 ms    | 10.33 ms    | 10.78 ms    |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.9139      | 0.6658      | 0.9877      | 0.9544      | 0.6521      |

## Docker Results for 3 GB 3 Core:

### CPU Testing:

Results for Docker based **CPU Testing** where Max-Prime = 20000 - test case 1

```
root@03e0f2f95d9d:/# ./cpu_bash_script.sh
Running First CPU Test: High Prime Number Calculation
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 7.0151s
total number of events: 10000
total time taken by event execution: 7.0139
per-request statistics:
  min: 0.63ms
  avg: 0.70ms
  max: 6.83ms
  approx. 95 percentile: 0.81ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 7.0139/0.00
```

### **Test Execution Summary:**

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.70 ms     | 0.66 ms     | 0.68 ms     | 0.72 ms     | 0.76 ms     |
| Max. time taken                      | 6.83 ms     | 7.21 ms     | 6.25 ms     | 6.75 ms     | 6.82 ms     |
| Min. time taken                      | 0.63 ms     | 0.63 ms     | 0.63 ms     | 0.63 ms     | 0.63 ms     |
| Total time taken for event execution | 7.0139      | 0.7752      | 0.7786      | 0.6998      | 0.7725      |

Results for Docker based **CPU Testing** where Max-Prime = 10000 - test case 2

```
Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
total time:                                0.9864s
total number of events:                    10000
total time taken by event execution: 3.9425
per-request statistics:
  min:                                     0.26ms
  avg:                                     0.39ms
  max:                                     30.86ms
  approx. 95 percentile:                   0.35ms

Threads fairness:
  events (avg/stddev):                   2500.0000/49.05
  execution time (avg/stddev):          0.9856/0.00
```

```
Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
total time:                                0.9831s
total number of events:                    10000
total time taken by event execution: 3.9298
per-request statistics:
  min:                                     0.27ms
  avg:                                     0.39ms
  max:                                     30.62ms
  approx. 95 percentile:                   0.35ms

Threads fairness:
  events (avg/stddev):                   2500.0000/31.00
  execution time (avg/stddev):          0.9824/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.38 ms     | 0.39 ms     | 0.39 ms     | 0.39 ms     | 0.39 ms     |
| Max. time taken                      | 30.86 ms    | 30.86 ms    | 30.62 ms    | 30.66 ms    | 30.85 ms    |
| Min. time taken                      | 0.26 ms     | 0.26 ms     | 0.27 ms     | 0.27 ms     | 0.27 ms     |
| Total time taken for event execution | 3.0139      | 3.9425      | 3.9298      | 3.6998      | 3.7725      |

### File I/O Testing:

Docker results for **File I/O Testing** for 3 GB RAM and 3 Core for Sequential Write

```
Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b: Written 250Mb Total transferred 250Mb (907.23Mb/sec)
58062.55 Requests/sec executed

Test execution summary:
total time: 0.2756s
total number of events: 16000
total time taken by event execution: 0.0875
per-request statistics:
  min: 0.00ms
  avg: 0.01ms
  max: 0.63ms
  approx. 95 percentile: 0.01ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 0.0875/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
```



### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.86 ms     | 0.86 ms     | 0.62 ms     | 0.66 ms     | 0.85 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0139      | 0.9425      | 0.9298      | 0.6998      | 0.7725      |

Docker results for **File I/O Testing** for 3 GB RAM and 3 Core for Random Read

```
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (6.4373Gb/sec)
421877.47 Requests/sec executed

Test execution summary:
  total time: 0.0237s
  total number of events: 10000
  total time taken by event execution: 0.0225
  per-request statistics:
    min: 0.00ms
    avg: 0.00ms
    max: 0.54ms
    approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.0225/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.54 ms     | 0.55 ms     | 0.55 ms     | 0.55 ms     | 0.55 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0255      | 0.5645      | 0.2589      | 0.1588      | 0.1689      |

### Memory Testing:

Docker results for **Memory Testing** for 3GB RAM and 3 Core for Sequential Memory Access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (5776658.28 ops/sec)

250.00 MB transferred (5641.27 MB/sec)

Test execution summary:
  total time:                0.0443s
  total number of events:    256000
  total time taken by event execution: 0.0357
  per-request statistics:
    min:                     0.00ms
    avg:                     0.00ms
    max:                     0.11ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0357/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.11 ms     | 0.12 ms     | 0.15 ms     | 0.16 ms     | 0.18 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0357      | 0.0645      | 0.0655      | 0.0887      | 0.0582      |

Docker results for **Memory Testing** for 3GB RAM and 3 Core for Random memory access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (6162442.91 ops/sec)

250.00 MB transferred (6018.01 MB/sec)

Test execution summary:
  total time:                                0.0415s
  total number of events:                    256000
  total time taken by event execution: 0.0323
  per-request statistics:
    min:                                     0.00ms
    avg:                                     0.00ms
    max:                                     0.36ms
    approx. 95 percentile:                  0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0323/0.00
```

### Test Execution Summary:

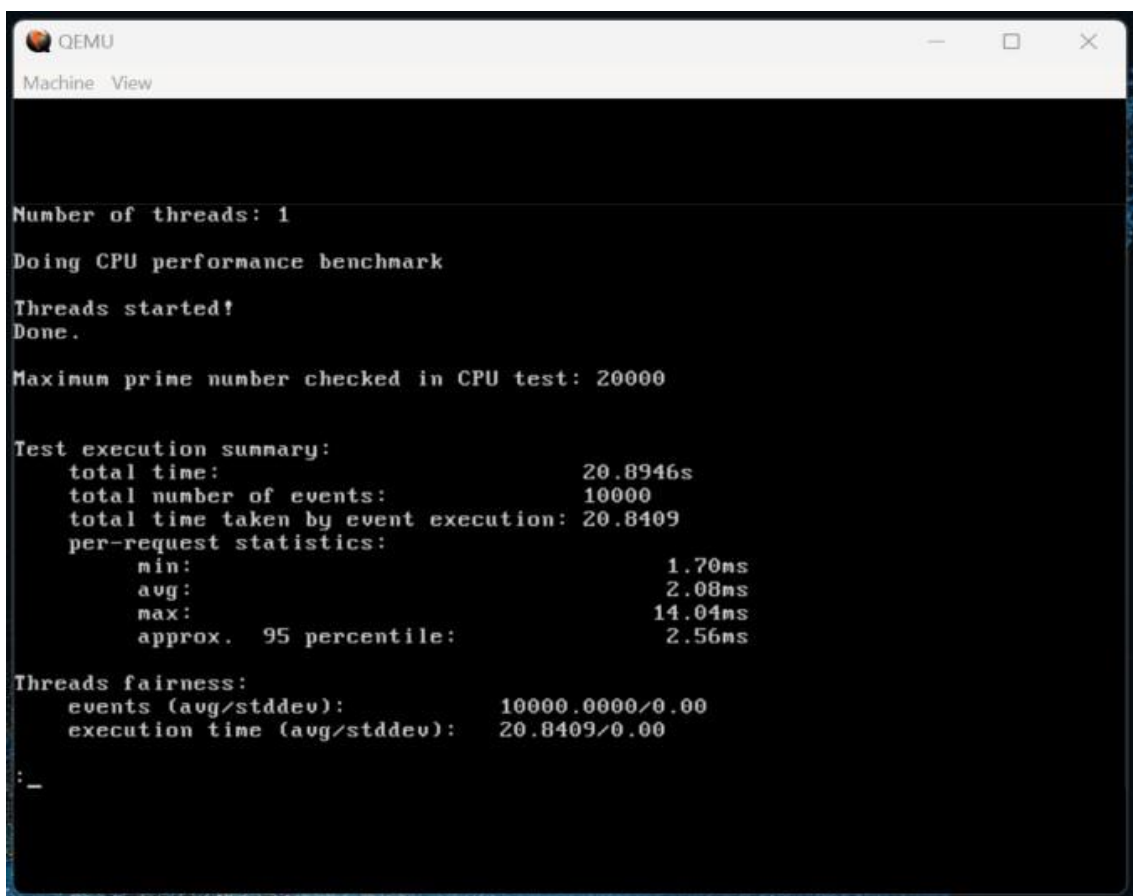
|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.36 ms     | 0.35 ms     | 0.38 ms     | 0.36 ms     | 0.35 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0323      | 0.0528      | 0.0352      | 0.0874      | 0.0458      |

### 3. Configuration: 3 GB RAM & 6 Core

#### QEMU- Raw disk image:

#### CPU Testing:

Result for **CPU Testing** where Max-Prime = 20000 - test case 1

A screenshot of a QEMU terminal window. The window title is "QEMU" with standard window controls. The terminal output shows a CPU performance benchmark. It starts with "Number of threads: 1", followed by "Doing CPU performance benchmark", "Threads started!", and "Done.". Then it reports "Maximum prime number checked in CPU test: 20000". A "Test execution summary:" section follows, listing: "total time: 20.8946s", "total number of events: 10000", "total time taken by event execution: 20.8409", and "per-request statistics:" with sub-values for min (1.70ms), avg (2.08ms), max (14.04ms), and approx. 95 percentile (2.56ms). Finally, it shows "Threads fairness:" with "events (avg/stddev): 10000.0000/0.00" and "execution time (avg/stddev): 20.8409/0.00". The prompt is ":".

```
QEMU
Machine: View

Number of threads: 1
Doing CPU performance benchmark
Threads started!
Done.
Maximum prime number checked in CPU test: 20000

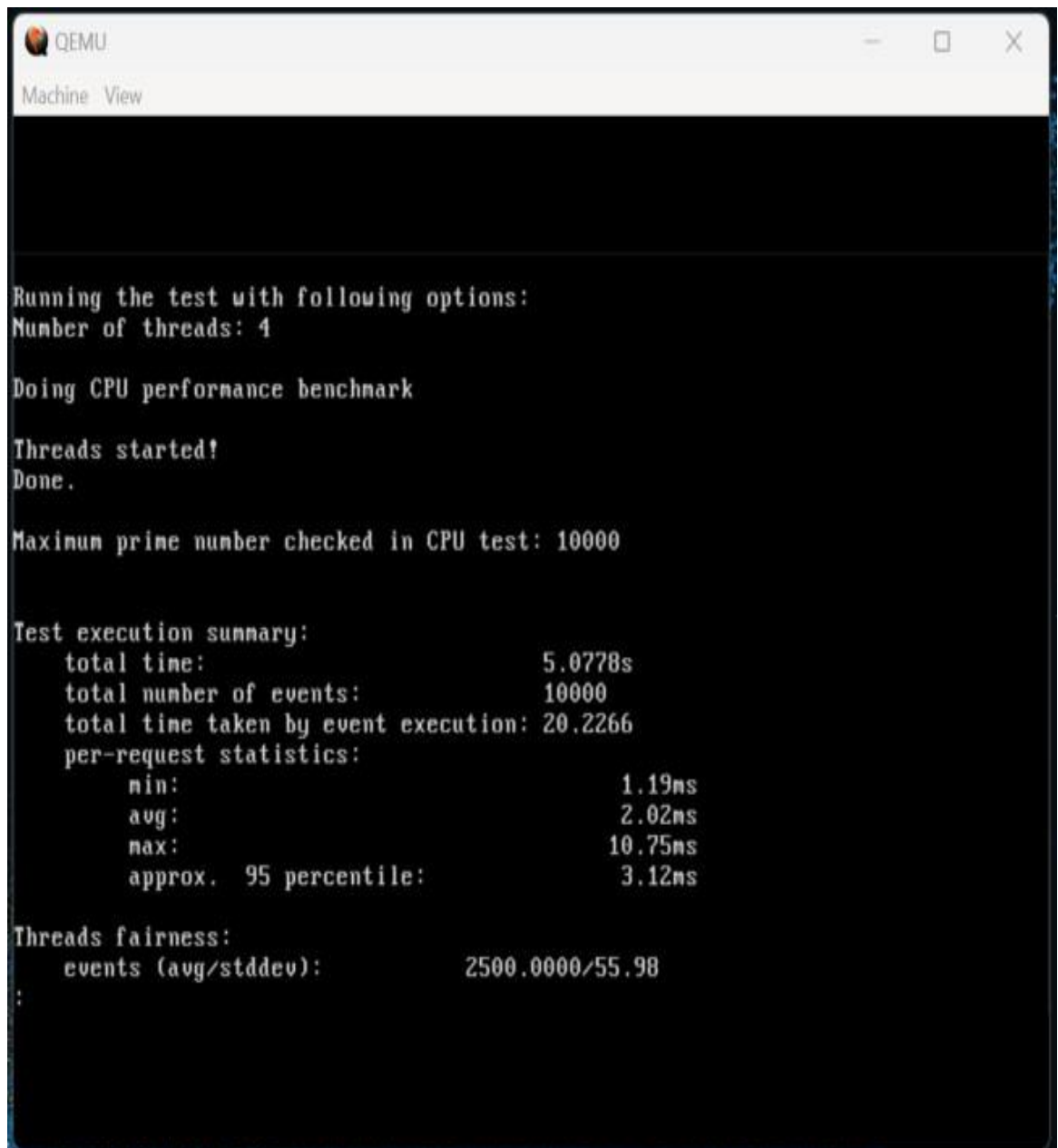
Test execution summary:
total time:                20.8946s
total number of events:    10000
total time taken by event execution: 20.8409
per-request statistics:
    min:                    1.70ms
    avg:                    2.08ms
    max:                    14.04ms
    approx. 95 percentile:  2.56ms

Threads fairness:
  events (avg/stddev):    10000.0000/0.00
  execution time (avg/stddev): 20.8409/0.00
:
_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 2.08 ms     | 2.10 ms     | 2.06 ms     | 2.09 ms     | 2.15 ms     |
| Max. time taken                      | 14.04 ms    | 14.35 ms    | 14.38 ms    | 14.36 ms    | 14.35 ms    |
| Min. time taken                      | 1.70 ms     | 1.62 ms     | 1.72 ms     | 1.78 ms     | 1.76 ms     |
| Total time taken for event execution | 20.8409     | 20.8856     | 20.8896     | 20.8875     | 20.7756     |

Result for **CPU Testing** where Max-Prime = 10000 - test case 2



```
QEMU
Machine View

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
total time: 5.0778s
total number of events: 10000
total time taken by event execution: 20.2266
per-request statistics:
  min: 1.19ms
  avg: 2.02ms
  max: 10.75ms
  approx. 95 percentile: 3.12ms

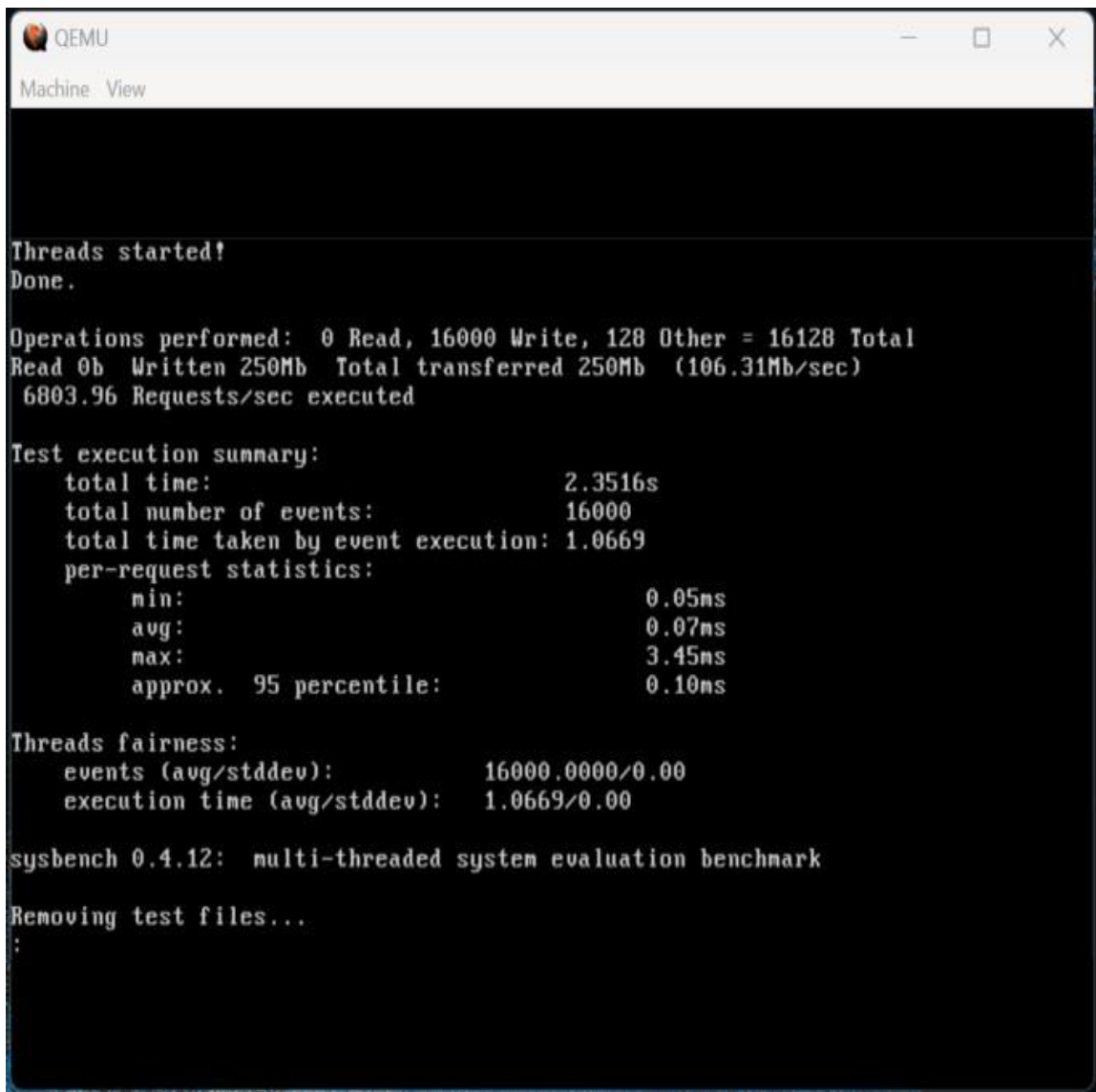
Threads fairness:
  events (avg/stddev): 2500.0000/55.98
:
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 2.02 ms     | 2.01 ms     | 2.06 ms     | 2.09 ms     | 2.15 ms     |
| Max. time taken                      | 10.75 ms    | 10.35 ms    | 10.38 ms    | 10.36 ms    | 10.35 ms    |
| Min. time taken                      | 1.19 ms     | 1.62 ms     | 1.72 ms     | 1.78 ms     | 1.76 ms     |
| Total time taken for event execution | 20.2266     | 20.4585     | 20.6522     | 20.7588     | 20.3125     |

### File I/O Testing:

QEMU qcow2 Result for **File I/O Testing** for 3 GB RAM and 6 Core for Sequential Write



```
QEMU
Machine View

Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (106.31Mb/sec)
6803.96 Requests/sec executed

Test execution summary:
total time: 2.3516s
total number of events: 16000
total time taken by event execution: 1.0669
per-request statistics:
  min: 0.05ms
  avg: 0.07ms
  max: 3.45ms
  approx. 95 percentile: 0.10ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 1.0669/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.07 ms     | 0.06 ms     | 0.07 ms     | 0.05 ms     | 0.06 ms     |
| Max. time taken                      | 3.35 ms     | 3.58 ms     | 3.45 ms     | 3.55 ms     | 3.57 ms     |
| Min. time taken                      | 0.05 ms     | 0.02 ms     | 0.05 ms     | 0.03 ms     | 0.05 ms     |
| Total time taken for event execution | 1.0558      | 1.0877      | 1.0669      | 1.0778      | 1.0551      |

QEMU raw result for **File I/O Testing** for 3 GB RAM and 6 Core for Random Read

```
QEMU
Machine View

Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (755.01Mb/sec)
48320.49 Requests/sec executed

Test execution summary:
total time: 0.2070s
total number of events: 10000
total time taken by event execution: 0.1841
per-request statistics:
  min: 0.01ms
  avg: 0.02ms
  max: 1.56ms
  approx. 95 percentile: 0.02ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.1841/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

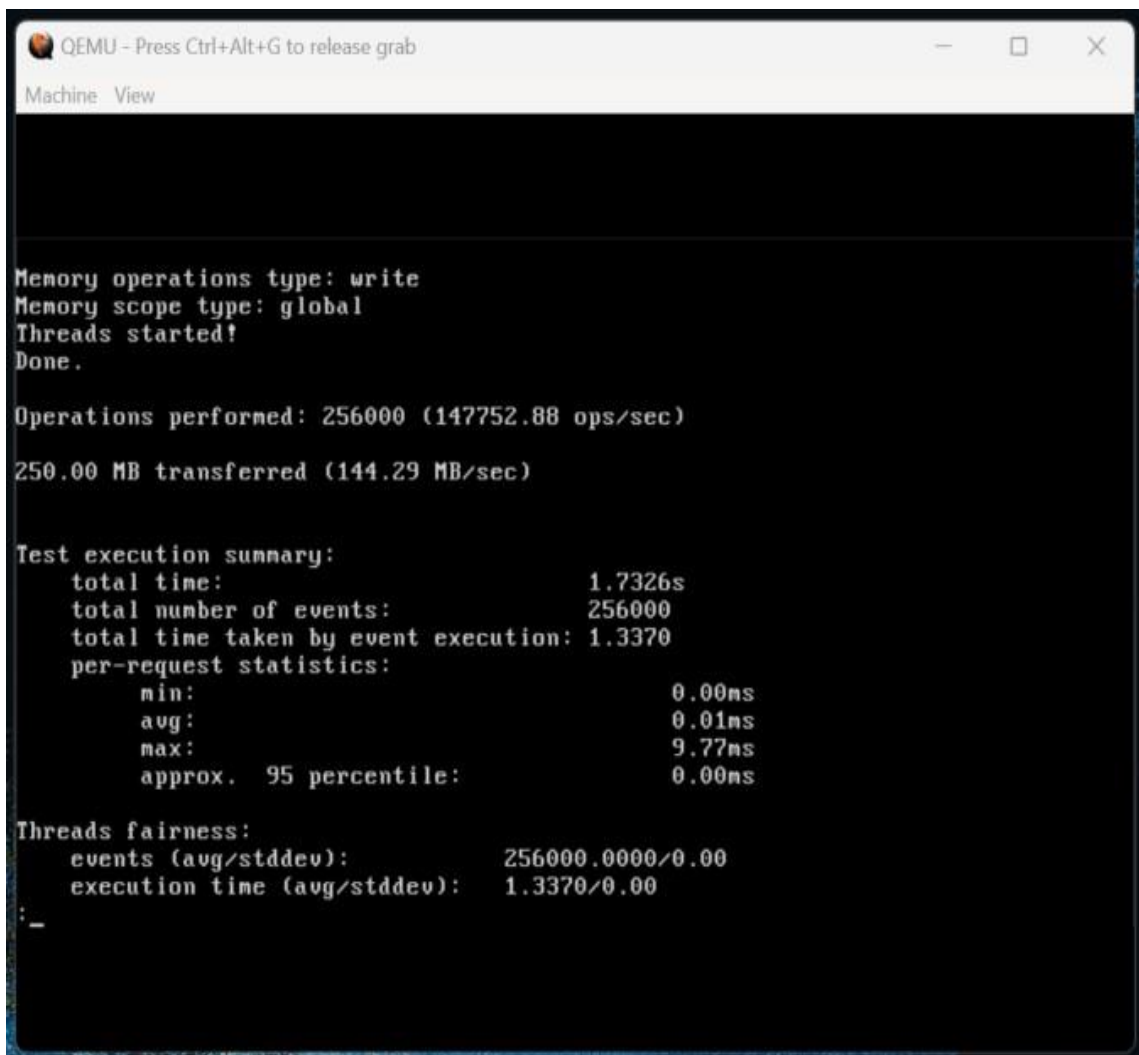
Removing test files...
:~
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.07 ms     | 0.06 ms     | 0.07 ms     | 0.05 ms     | 0.06 ms     |
| Max. time taken                      | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 0.1841      | 0.0877      | 0.0669      | 0.0778      | 0.0551      |

### Memory Testing:

QEMU raw results for **Memory Testing** for 3GB RAM and 6 Core for Sequential Memory Access – Total memory size = 250 MB

A screenshot of a QEMU terminal window. The title bar reads "QEMU - Press Ctrl+Alt+G to release grab". Below the title bar is a menu bar with "Machine" and "View". The terminal output shows the following text:

```
Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (147752.88 ops/sec)
250.00 MB transferred (144.29 MB/sec)

Test execution summary:
  total time: 1.7326s
  total number of events: 256000
  total time taken by event execution: 1.3370
  per-request statistics:
    min: 0.00ns
    avg: 0.01ns
    max: 9.77ns
    approx. 95 percentile: 0.00ns

Threads fairness:
  events (avg/stddev): 256000.0000/0.00
  execution time (avg/stddev): 1.3370/0.00
:_
```



### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 9.97 ms     | 9.55 ms     | 9.64 ms     | 9.55 ms     | 9.45 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 1.3370      | 1.5587      | 1.3365      | 1.3856      | 1.8857      |

QEMU raw results for **Memory Testing** for 3GB RAM and 6 Core for Random Memory Access – Total memory size = 250 MB

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (150193.44 ops/sec)
250.00 MB transferred (146.67 MB/sec)

Test execution summary:
  total time: 1.7045s
  total number of events: 256000
  total time taken by event execution: 1.2725
  per-request statistics:
    min: 0.00ms
    avg: 0.00ms
    max: 12.87ms
    approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 256000.0000/0.00
  execution time (avg/stddev): 1.2725/0.00
:
```

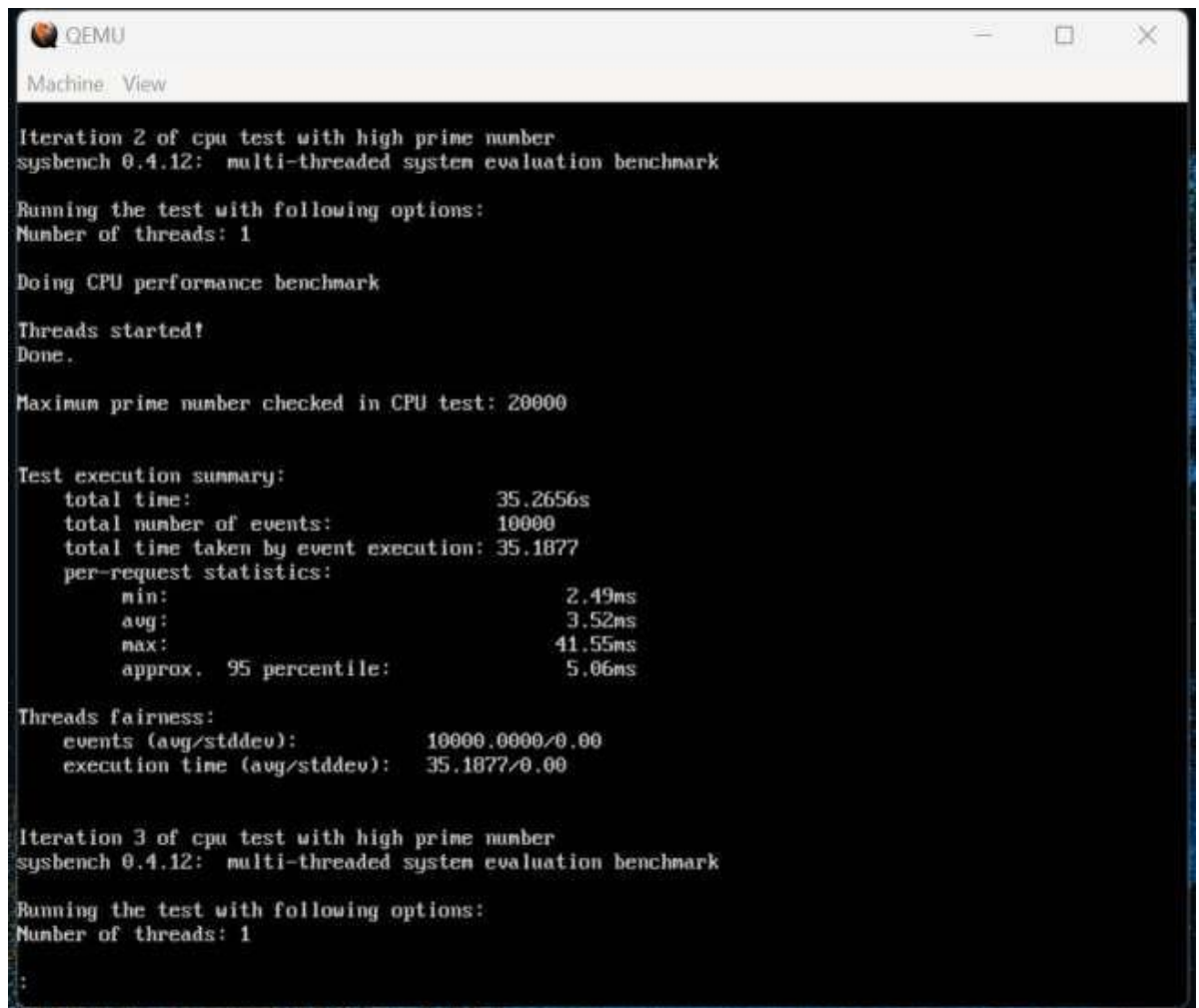
### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 11.55 ms    | 11.55 ms    | 11.64 ms    | 11.55 ms    | 11.45 ms    |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 1.2725      | 1.5587      | 1.3365      | 1.3856      | 1.8857      |

### QEMU- Qcow2 disk image:

### CPU Testing:

Result for **CPU Testing** where Max-Prime = 20000 - test case 1



```
QEMU
Machine: View

Iteration 2 of cpu test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
  total time:                35.2656s
  total number of events:    10000
  total time taken by event execution: 35.1877
  per-request statistics:
    min:                     2.49ms
    avg:                     3.52ms
    max:                     41.55ms
    approx. 95 percentile:   5.06ms

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 35.1877/0.00

Iteration 3 of cpu test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

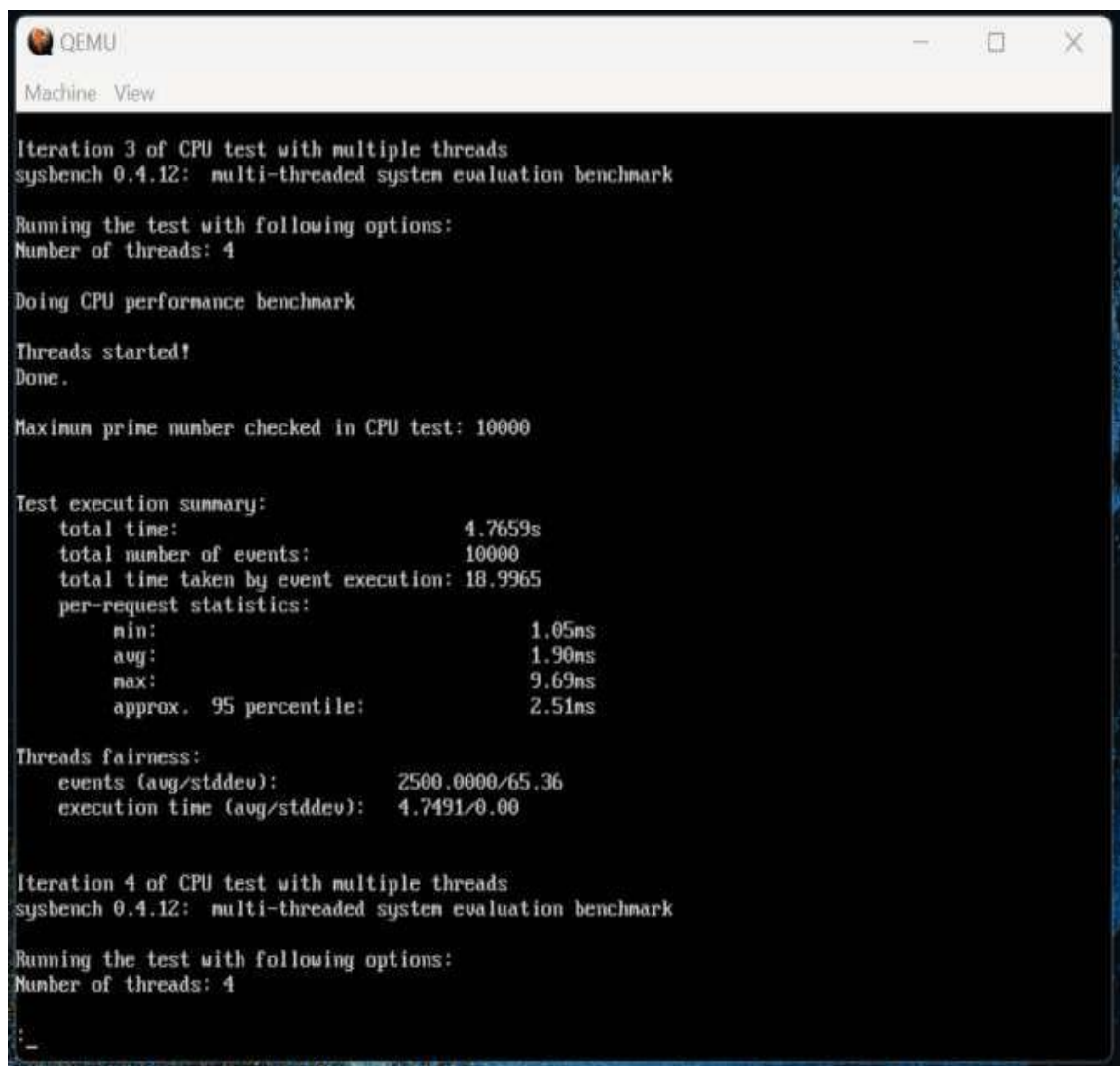
Running the test with following options:
Number of threads: 1

:
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 3.52 ms     | 3.54 ms     | 3.57 ms     | 3.87 ms     | 3.63 ms     |
| Max. time taken                            | 41.55 ms    | 42.09 ms    | 41.23 ms    | 41.88 ms    | 41.96 ms    |
| Min. time taken                            | 2.49 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken<br>for event<br>execution | 35.1877     | 35.2857     | 35.1147     | 35.2248     | 35.4896     |

Result for **CPU Testing** where Max-Prime = 10000 - test case 2



```
QEMU
Machine: View

Iteration 3 of CPU test with multiple threads
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
total time: 4.7659s
total number of events: 10000
total time taken by event execution: 18.9965
per-request statistics:
  min: 1.05ms
  avg: 1.90ms
  max: 9.69ms
  approx. 95 percentile: 2.51ms

Threads fairness:
  events (avg/stddev): 2500.0000/65.36
  execution time (avg/stddev): 4.7491/0.00

Iteration 4 of CPU test with multiple threads
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 1.90 ms     | 1.91 ms     | 1.57 ms     | 1.87 ms     | 1.63 ms     |
| Max. time taken                            | 9.69 ms     | 9.09 ms     | 9.23 ms     | 9.88 ms     | 9.96 ms     |
| Min. time taken                            | 1.05 ms     | 1.01 ms     | 1.07 ms     | 1.12 ms     | 1.05 ms     |
| Total time taken<br>for event<br>execution | 18.9965     | 18.2857     | 18.1147     | 18.2248     | 18.4896     |

### File I/O Testing:

QEMU qcow2 results for **File I/O Testing** for 3 GB RAM and 6 Core for Sequential Write

```
QEMU
Machine View

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (42.818Mb/sec)
2740.35 Requests/sec executed

Test execution summary:
total time: 5.8387s
total number of events: 16000
total time taken by event execution: 2.3941
per-request statistics:
  min: 0.07ms
  avg: 0.15ms
  max: 7.38ms
  approx. 95 percentile: 0.33ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 2.3941/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:-
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.15 ms     | 0.17 ms     | 0.19 ms     | 0.14 ms     | 0.16 ms     |
| Max. time taken                      | 7.38 ms     | 7.39 ms     | 7.23 ms     | 7.88 ms     | 7.96 ms     |
| Min. time taken                      | 0.07 ms     | 0.01 ms     | 0.07 ms     | 0.12 ms     | 0.05 ms     |
| Total time taken for event execution | 2.3941      | 2.2857      | 2.1147      | 2.2248      | 2.4896      |

QEMU qcow2 results for **File I/O Testing** for 3 GB RAM and 6 Core for Random Read

```
QEMU
Machine View
Number of threads: 1

Extra file open flags: 0
128 files, 2.3438Mb each
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (321.28Mb/sec)
20561.67 Requests/sec executed

Test execution summary:
  total time:                0.4863s
  total number of events:    10000
  total time taken by event execution: 0.4330
  per-request statistics:
    min:                     0.02ms
    avg:                     0.04ms
    max:                     5.58ms
    approx. 95 percentile:   0.05ms

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 0.4330/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

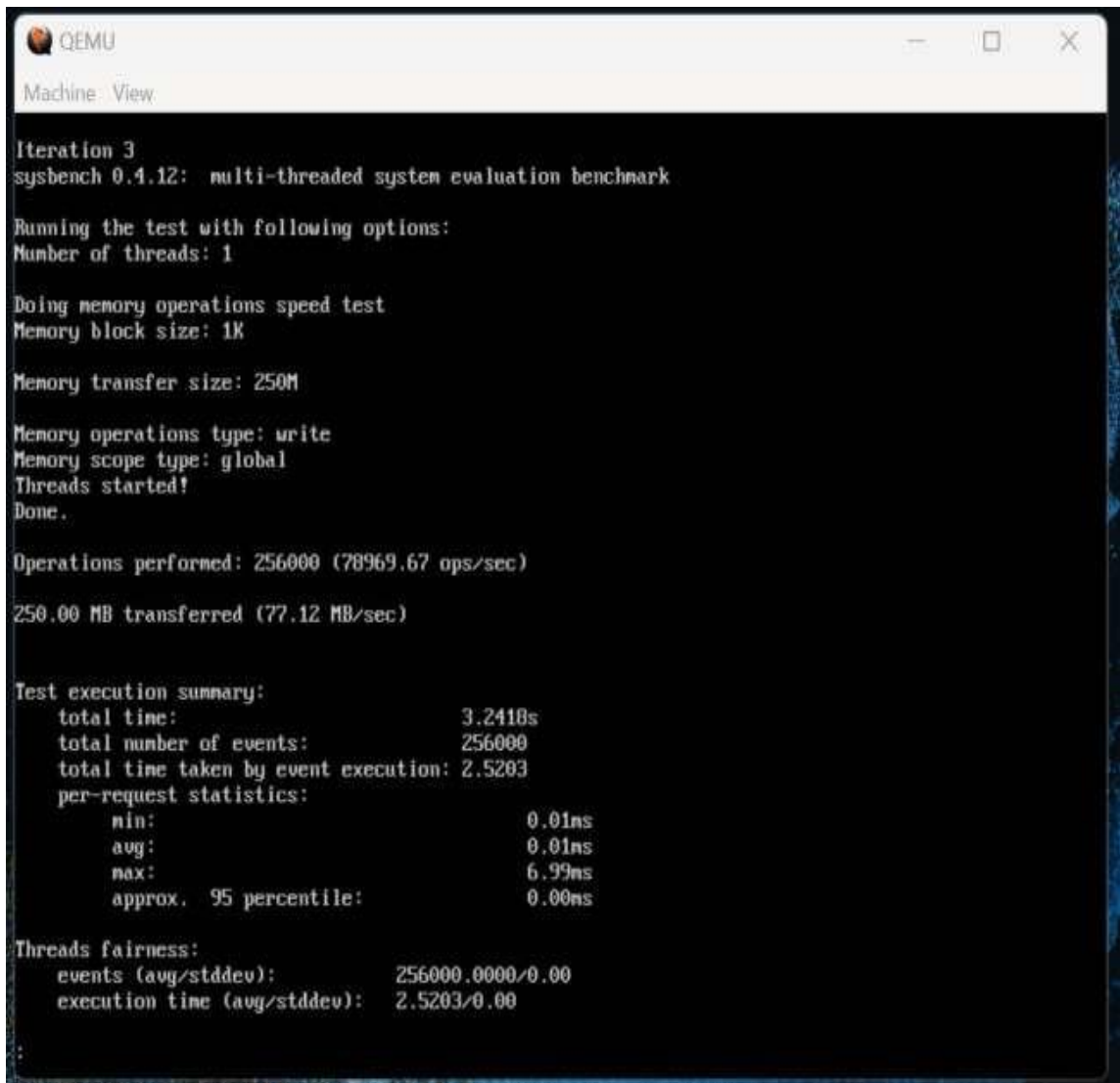
Removing test files...
:
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.04 ms     | 0.07 ms     | 0.09 ms     | 0.04 ms     | 0.06 ms     |
| Max. time taken                      | 5.58 ms     | 5.59 ms     | 5.53 ms     | 5.58 ms     | 5.56 ms     |
| Min. time taken                      | 0.07 ms     | 0.01 ms     | 0.07 ms     | 0.12 ms     | 0.05 ms     |
| Total time taken for event execution | 0.4330      | 0.2857      | 0.1147      | 0.2248      | 0.4896      |

### Memory Testing:

QEMU qcow2 results for **Memory Testing** for 3GB RAM and 6 Core for Sequential Memory Access – Total memory size = 250 MB

A screenshot of a QEMU terminal window. The window title is "QEMU" with a logo on the left and standard window controls on the right. Below the title bar, it says "Machine: View". The terminal content shows the execution of sysbench 0.4.12, specifically the multi-threaded system evaluation benchmark. It details the test configuration: 1 thread, memory operations speed test, 1K block size, 250M transfer size, write operations, and global scope. The test results show 256,000 operations performed at 78969.67 ops/sec, with 250.00 MB transferred at 77.12 MB/sec. A detailed test execution summary follows, including total time (3.2418s), total events (256,000), total time taken by event execution (2.5203s), and per-request statistics (min: 0.01ns, avg: 0.01ns, max: 6.99ns, approx. 95 percentile: 0.00ns). Finally, it shows threads fairness: events (avg/stddev): 256000.0000/0.00 and execution time (avg/stddev): 2.5203/0.00.

```
QEMU
Machine: View

Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (78969.67 ops/sec)
250.00 MB transferred (77.12 MB/sec)

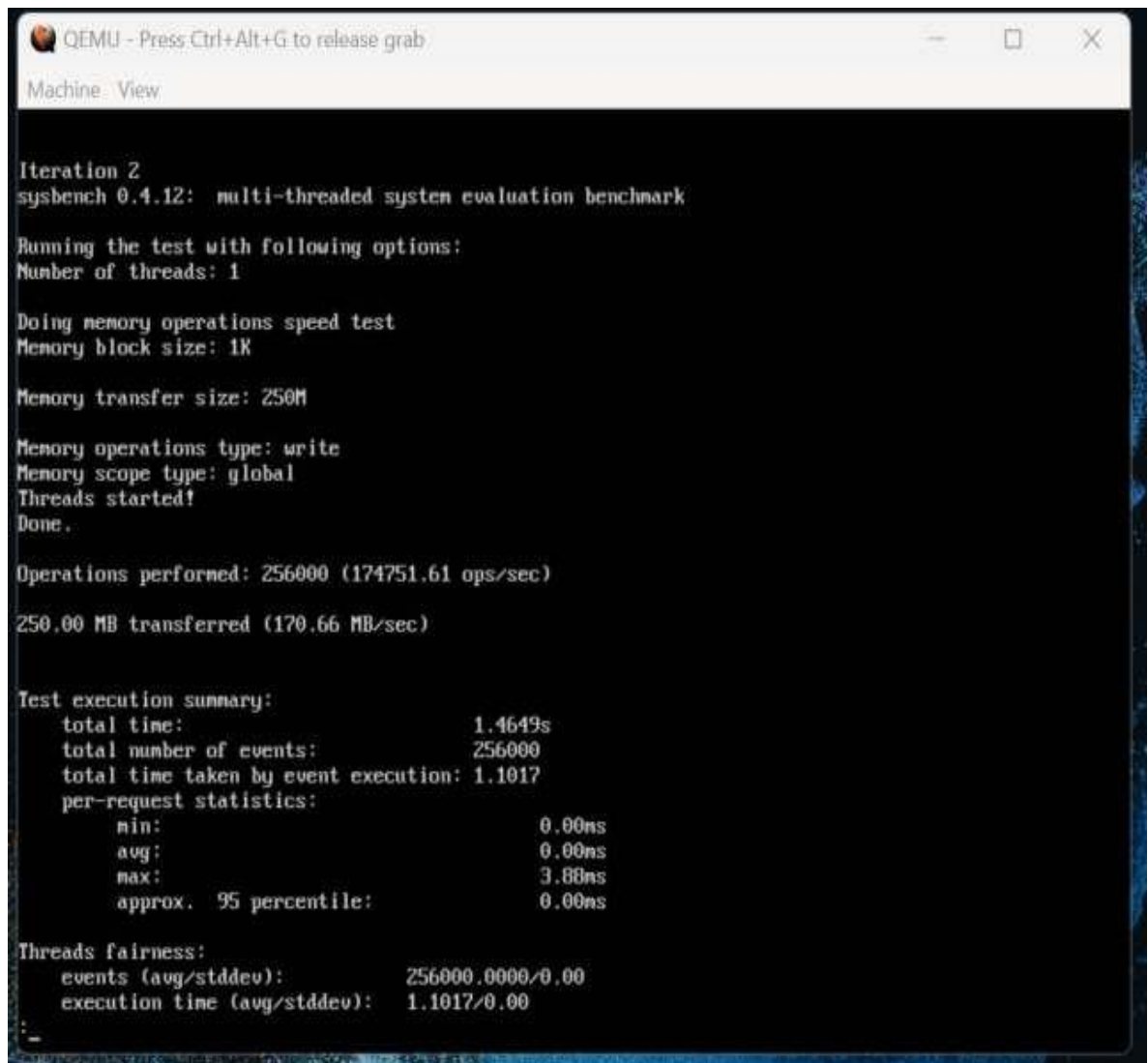
Test execution summary:
  total time:                3.2418s
  total number of events:    256000
  total time taken by event execution: 2.5203
  per-request statistics:
    min:                      0.01ns
    avg:                      0.01ns
    max:                      6.99ns
    approx. 95 percentile:    0.00ns

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 2.5203/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 6.99 ms     | 6.59 ms     | 6.53 ms     | 6.58 ms     | 6.56 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 2.5203      | 2.2857      | 2.1147      | 2.2248      | 2.4896      |

QEMU qcow2 results for **Memory Testing** for 3GB RAM and 6 Core for Random Memory Access – Total memory size = 250 MB

A screenshot of a QEMU terminal window. The title bar reads "QEMU - Press Ctrl+Alt+G to release grab". Below the title bar, it says "Machine: View". The terminal output shows the execution of sysbench 0.4.12, specifically the multi-threaded system evaluation benchmark. It details the test configuration: 1 thread, memory operations speed test, 1K block size, 250M transfer size, write operations, and global scope. The test results show 256,000 operations performed at 174,751.61 ops/sec, with 250.00 MB transferred at 170.66 MB/sec. A test execution summary follows, showing a total time of 1.4649s, 256,000 events, and a total time taken by event execution of 1.1017s. Per-request statistics show a minimum of 0.00ns, an average of 0.00ns, a maximum of 3.88ns, and an approximate 95th percentile of 0.00ns. Finally, thread fairness is reported as 256,000.0000/0.00 for events and 1.1017/0.00 for execution time.

```
QEMU - Press Ctrl+Alt+G to release grab
Machine: View

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (174751.61 ops/sec)
250.00 MB transferred (170.66 MB/sec)

Test execution summary:
  total time:                1.4649s
  total number of events:     256000
  total time taken by event execution: 1.1017
  per-request statistics:
    min:                      0.00ns
    avg:                       0.00ns
    max:                       3.88ns
    approx. 95 percentile:    0.00ns

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 1.1017/0.00
_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 3.88 ms     | 3.59 ms     | 3.53 ms     | 3.58 ms     | 3.56 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 1.1017      | 1.2857      | 1.1147      | 1.2248      | 1.4896      |

### Docker Results for 3 GB 6 Core:

#### CPU Testing:

Results for Docker based **CPU Testing** where Max-Prime = 20000 - test case 1

```
Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 7.0295s
total number of events: 10000
total time taken by event execution: 7.0284
per-request statistics:
  min: 0.63ms
  avg: 0.70ms
  max: 4.18ms
  approx. 95 percentile: 0.80ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 7.0284/0.00
```



### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.70 ms     | 0.68 ms     | 0.85 ms     | 0.55 ms     | 0.73 ms     |
| Max. time taken                      | 4.18 ms     | 4.59 ms     | 4.22 ms     | 4.38 ms     | 4.26 ms     |
| Min. time taken                      | 0.63 ms     | 0.72 ms     | 0.65 ms     | 0.66 ms     | 0.61 ms     |
| Total time taken for event execution | 7.0284      | 7.2587      | 7.4456      | 7.1489      | 7.5548      |

Results for Docker based **CPU Testing** where Max-Prime = 10000 - test case 2

```
Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
  total time:                0.7308s
  total number of events:    10000
  total time taken by event execution: 2.9200
  per-request statistics:
    min:                     0.27ms
    avg:                     0.29ms
    max:                     1.14ms
    approx. 95 percentile:   0.32ms

Threads fairness:
  events (avg/stddev):       2500.0000/9.35
  execution time (avg/stddev): 0.7300/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.29 ms     | 0.30 ms     | 0.35 ms     | 0.38 ms     | 0.33 ms     |
| Max. time taken                      | 1.14 ms     | 1.59 ms     | 1.22 ms     | 1.38 ms     | 1.26 ms     |
| Min. time taken                      | 0.27 ms     | 0.72 ms     | 0.65 ms     | 0.66 ms     | 0.61 ms     |
| Total time taken for event execution | 2.9200      | 2.2587      | 2.4456      | 2.1489      | 2.5548      |

### File I/O Testing:

Docker results for **File I/O Testing** for 3 GB RAM and 6 Core for Sequential Write

```
Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (928.6Mb/sec)
59430.39 Requests/sec executed

Test execution summary:
total time: 0.2692s
total number of events: 16000
total time taken by event execution: 0.0909
per-request statistics:
min: 0.00ms
avg: 0.01ms
max: 0.75ms
approx. 95 percentile: 0.01ms

Threads fairness:
events (avg/stddev): 16000.0000/0.00
execution time (avg/stddev): 0.0909/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.75 ms     | 0.79 ms     | 0.72 ms     | 0.78 ms     | 0.77 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0909      | 0.2587      | 0.4456      | 0.1489      | 0.5548      |

Docker results for **File I/O Testing** for 3 GB RAM and 6 Core for Random Read

```
Number of threads: 1

Extra file open flags: 0
128 files, 2.3438Mb each
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (5.5491Gb/sec)
363667.89 Requests/sec executed

Test execution summary:
  total time:                                0.0275s
  total number of events:                    10000
  total time taken by event execution: 0.0263
  per-request statistics:
    min:                                     0.00ms
    avg:                                     0.00ms
    max:                                     0.10ms
    approx. 95 percentile:                   0.00ms

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 0.0263/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.10 ms     | 0.11 ms     | 0.15 ms     | 0.18 ms     | 0.66 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0263      | 0.0587      | 0.0456      | 0.0489      | 0.0548      |

### Memory Testing:

Docker results for **Memory Testing** for 3GB RAM and 6 Core for Sequential Memory Access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (5342051.56 ops/sec)
250.00 MB transferred (5216.85 MB/sec)

Test execution summary:
  total time:                0.0479s
  total number of events:    256000
  total time taken by event execution: 0.0389
  per-request statistics:
    min:                     0.00ms
    avg:                     0.00ms
    max:                     0.25ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0389/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.25 ms     | 0.26 ms     | 0.27 ms     | 0.28 ms     | 0.26 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0389      | 0.0587      | 0.0456      | 0.0489      | 0.0548      |

Docker results for **Memory Testing** for 3GB RAM and 6 Core for Random Memory Access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (5980937.82 ops/sec)

250.00 MB transferred (5840.76 MB/sec)

Test execution summary:
total time: 0.0428s
total number of events: 256000
total time taken by event execution: 0.0330
per-request statistics:
  min: 0.00ms
  avg: 0.00ms
  max: 0.21ms
  approx. 95 percentile: 0.00ms

Threads fairness:
  events (avg/stddev): 256000.0000/0.00
  execution time (avg/stddev): 0.0330/0.00
```

### Test Execution Summary:

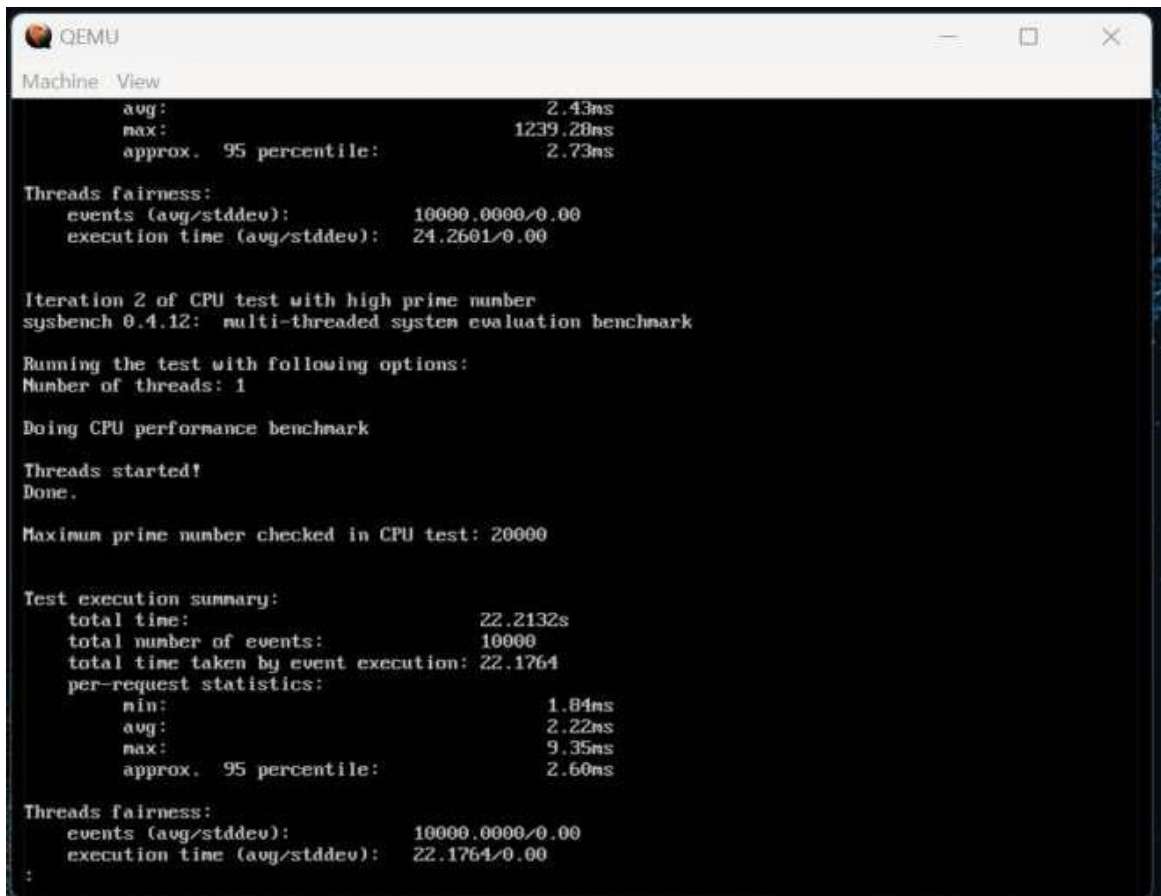
|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.21 ms     | 0.26 ms     | 0.27 ms     | 0.28 ms     | 0.26 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 0.0330      | 0.0378      | 0.0346      | 0.0458      | 0.0660      |

## 4. Configuration: 4 GB RAM & 8 Core

### QEMU- Raw disk image:

### CPU Testing:

Result for **CPU Testing** where Max-Prime = 20000 - test case 1

A screenshot of a QEMU terminal window. The window title is 'QEMU'. The terminal output shows the results of a CPU test. It includes statistics for 'avg:', 'max:', and 'approx. 95 percentile:' with values in nanoseconds. It also shows 'Threads fairness:' statistics for 'events (avg/stddev):' and 'execution time (avg/stddev):'. The test is identified as 'Iteration 2 of CPU test with high prime number' using 'sysbench 0.4.12: multi-threaded system evaluation benchmark'. It specifies 'Running the test with following options: Number of threads: 1' and 'Doing CPU performance benchmark'. The test status is 'Threads started!' followed by 'Done.'. The 'Maximum prime number checked in CPU test: 20000' is noted. A 'Test execution summary:' section provides a 'total time: 22.2132s', 'total number of events: 10000', and 'total time taken by event execution: 22.1764'. It also includes 'per-request statistics:' with 'min: 1.84ms', 'avg: 2.22ms', 'max: 9.35ms', and 'approx. 95 percentile: 2.60ms'. Finally, it repeats the 'Threads fairness:' statistics.

```
Machine: View
      avg:                2.43ms
      max:                1239.28ms
      approx. 95 percentile: 2.73ms

Threads fairness:
  events (avg/stddev):    10000.0000/0.00
  execution time (avg/stddev): 24.2601/0.00

Iteration 2 of CPU test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

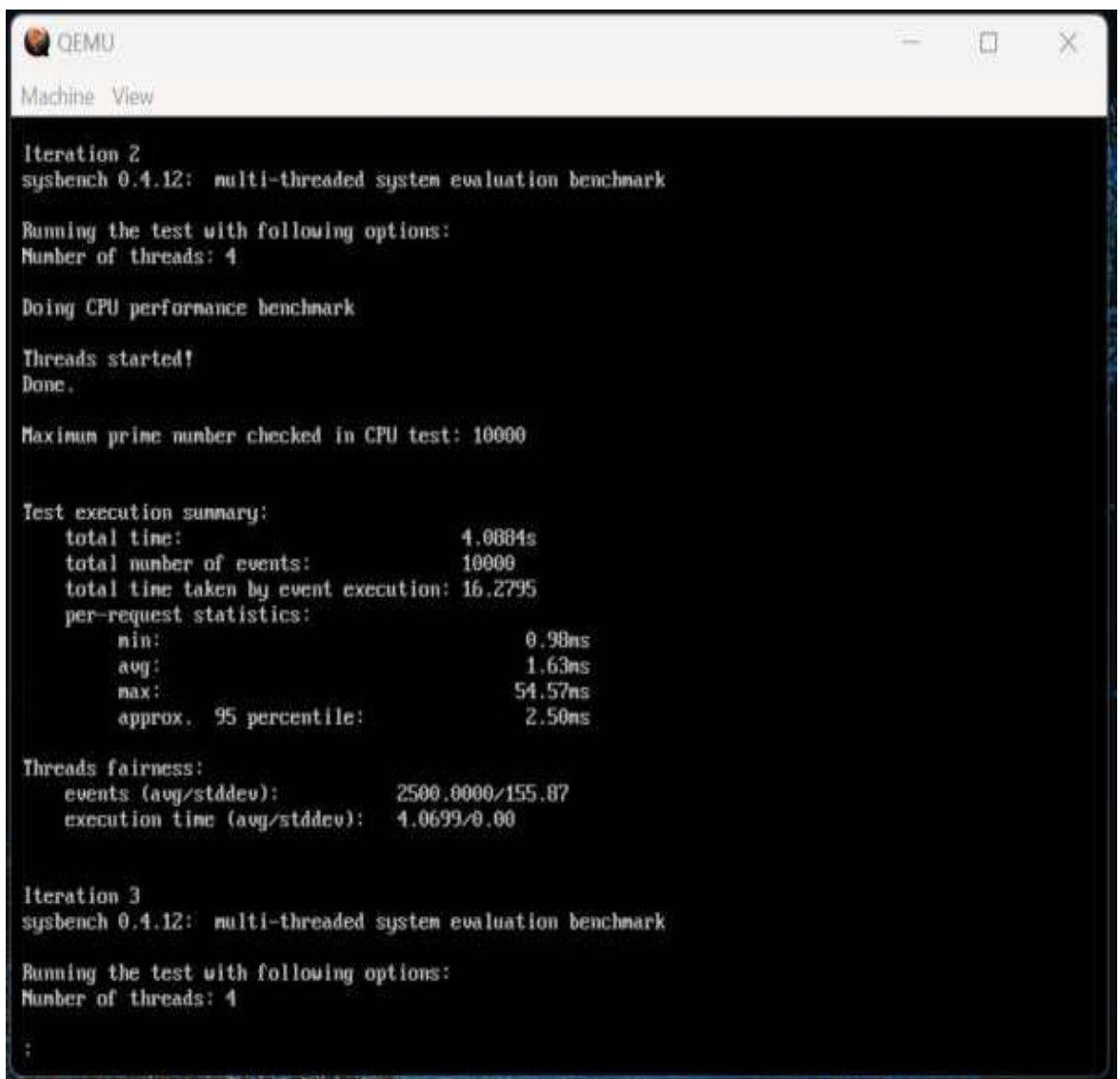
Test execution summary:
  total time:                22.2132s
  total number of events:    10000
  total time taken by event execution: 22.1764
  per-request statistics:
    min:                    1.84ms
    avg:                    2.22ms
    max:                    9.35ms
    approx. 95 percentile: 2.60ms

Threads fairness:
  events (avg/stddev):    10000.0000/0.00
  execution time (avg/stddev): 22.1764/0.00
:
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 2.22 ms     | 2.21 ms     | 2.14 ms     | 2.45 ms     | 2.38 ms     |
| Max. time taken                      | 9.35 ms     | 9.12 ms     | 9.48 ms     | 9.24 ms     | 9.65 ms     |
| Min. time taken                      | 1.84 ms     | 1.77 ms     | 1.78 ms     | 1.84 ms     | 1.83 ms     |
| Total time taken for event execution | 22.1764     | 22.5587     | 22.6248     | 22.0458     | 22.0660     |

Result for **CPU Testing** where Max-Prime = 10000 - test case 2



```
QEMU
Machine View

Iteration 2
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
total time: 4.0884s
total number of events: 10000
total time taken by event execution: 16.2795
per-request statistics:
  min: 0.98ms
  avg: 1.63ms
  max: 54.57ms
  approx. 95 percentile: 2.50ms

Threads fairness:
  events (avg/stddev): 2500.0000/155.87
  execution time (avg/stddev): 4.0699/0.00

Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

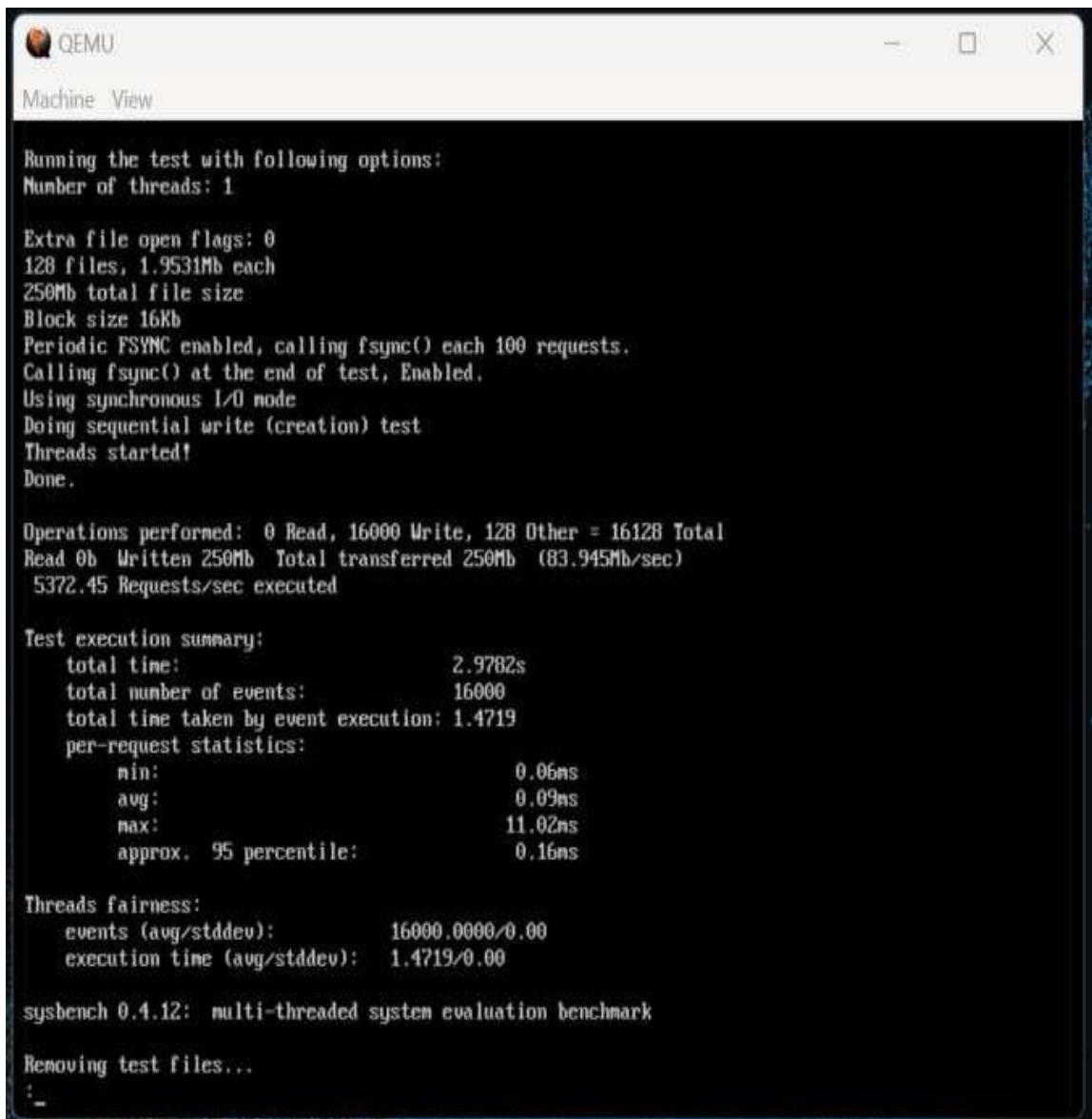
:
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 1.63 ms     | 2.21 ms     | 2.14 ms     | 2.45 ms     | 2.38 ms     |
| Max. time taken                      | 54.57 ms    | 54.12 ms    | 54.48 ms    | 54.24 ms    | 54.65 ms    |
| Min. time taken                      | 0.90 ms     | 0.77 ms     | 0.78 ms     | 0.84 ms     | 0.83 ms     |
| Total time taken for event execution | 16.2795     | 16.5587     | 16.6248     | 16.0458     | 16.0660     |

### File I/O Testing:

QEMU raw results for **File I/O Testing** for 4 GB RAM and 8 Core for Sequential Write



```
QEMU
Machine View

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (83.945Mb/sec)
5372.45 Requests/sec executed

Test execution summary:
total time: 2.9782s
total number of events: 16000
total time taken by event execution: 1.4719
per-request statistics:
  min: 0.06ms
  avg: 0.09ms
  max: 11.02ms
  approx. 95 percentile: 0.16ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 1.4719/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:_
```



### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.09 ms     | 0.08 ms     | 0.06 ms     | 0.05 ms     | 0.05 ms     |
| Max. time taken                            | 11.02 ms    | 11.12 ms    | 11.48 ms    | 11.24 ms    | 11.65 ms    |
| Min. time taken                            | 0.06 ms     | 0.07 ms     | 0.08 ms     | 0.04 ms     | 0.03 ms     |
| Total time taken<br>for event<br>execution | 1.4719      | 1.5587      | 1.6248      | 1.0458      | 11.0660     |

QEMU raw results for **File I/O Testing** for 4 GB RAM and 8 Core for Random Read

```
QEMU
Machine: View
Number of threads: 1

Extra file open flags: 0
128 files, 2.3438Mb each
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (595.52Mb/sec)
38113.35 Requests/sec executed

Test execution summary:
  total time:                0.2624s
  total number of events:    10000
  total time taken by event execution: 0.2366
  per-request statistics:
    min:                     0.01ms
    avg:                     0.02ms
    max:                     9.62ms
    approx. 95 percentile:   0.02ms

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 0.2366/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

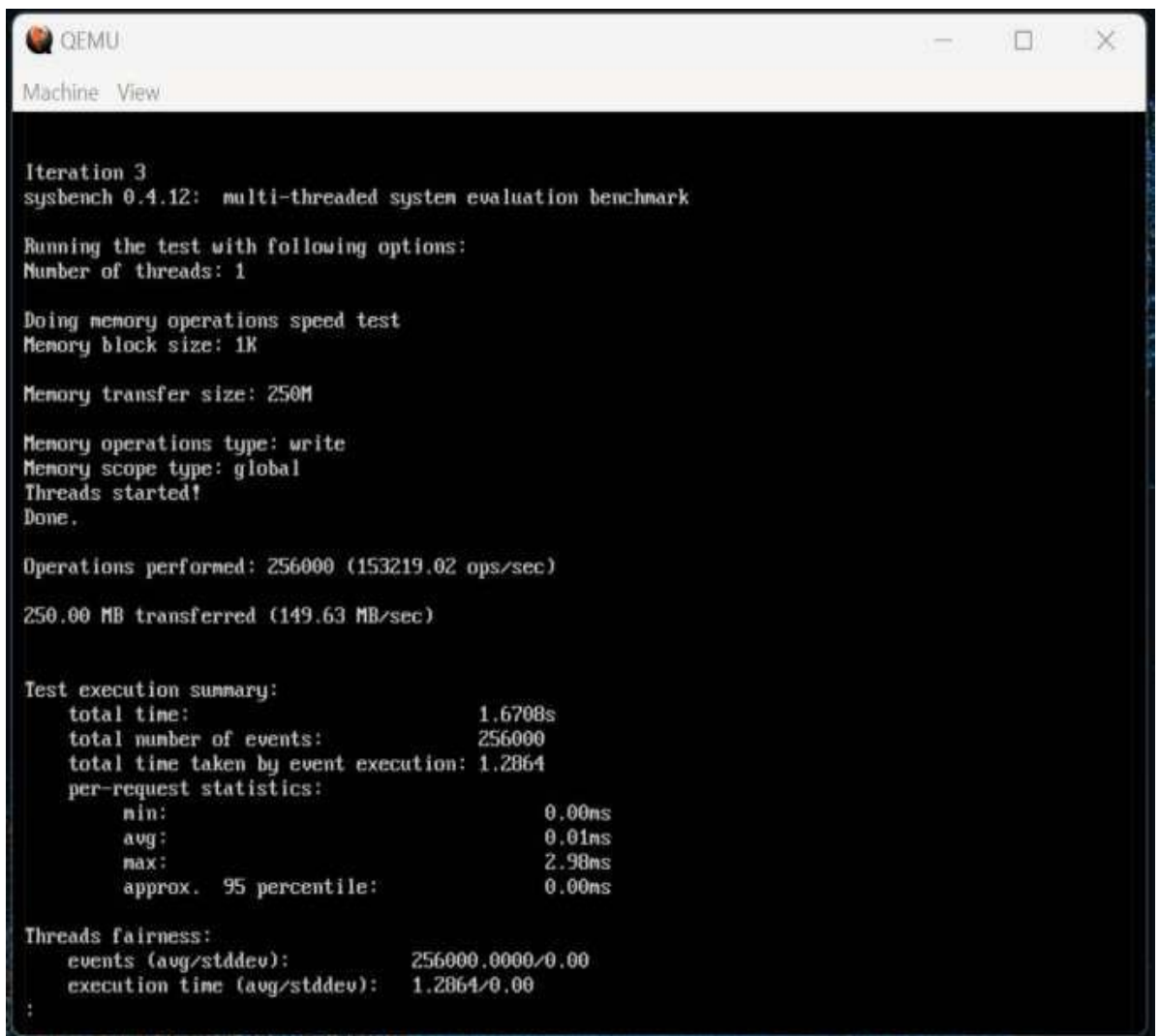
Removing test files...
_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.02 ms     | 0.08 ms     | 0.06 ms     | 0.05 ms     | 0.05 ms     |
| Max. time taken                      | 9.62 ms     | 9.12 ms     | 9.48 ms     | 9.24 ms     | 9.65 ms     |
| Min. time taken                      | 0.01 ms     | 0.07 ms     | 0.08 ms     | 0.04 ms     | 0.03 ms     |
| Total time taken for event execution | 0.2366      | 0.5587      | 0.6248      | 0.0458      | 0.0660      |

### Memory Testing:

QEMU raw results for **Memory Testing** for 4GB RAM and 8 Core for Sequential Memory Access – Total memory size = 250 MB

A screenshot of a QEMU terminal window. The window title is 'QEMU' with standard window controls. Below the title bar, there's a menu bar with 'Machine' and 'View'. The main terminal area has a black background with white text. The text shows the execution of 'sysbench 0.4.12: multi-threaded system evaluation benchmark'. It lists options: 'Number of threads: 1', 'Doing memory operations speed test', 'Memory block size: 1K', 'Memory transfer size: 250M', 'Memory operations type: write', 'Memory scope type: global', 'Threads started!', and 'Done.'. It then reports 'Operations performed: 256000 (153219.02 ops/sec)' and '250.00 MB transferred (149.63 MB/sec)'. A 'Test execution summary:' section follows, showing 'total time: 1.6708s', 'total number of events: 256000', 'total time taken by event execution: 1.2864', and 'per-request statistics' with min, avg, max, and 95 percentile values. Finally, it shows 'Threads fairness:' with 'events (avg/stddev): 256000.0000/0.00' and 'execution time (avg/stddev): 1.2864/0.00'.

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 2.98 ms     | 2.12 ms     | 2.48 ms     | 2.24 ms     | 2.65 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 1.2864      | 1.5077      | 1.6652      | 1.3215      | 1.554       |

QEMU raw results for **Memory Testing** for 4GB RAM and 8 Core for Random Memory Access – Total memory size = 250 MB

```
QEMU
Machine View

Iteration 5
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (97077.88 ops/sec)
250.00 MB transferred (94.80 MB/sec)

Test execution summary:
  total time:                2.6371s
  total number of events:     256000
  total time taken by event execution: 1.9482
  per-request statistics:
    min:                      0.00ms
    avg:                       0.01ms
    max:                       7.11ms
    approx. 95 percentile:    0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 1.9482/0.00
:_
```

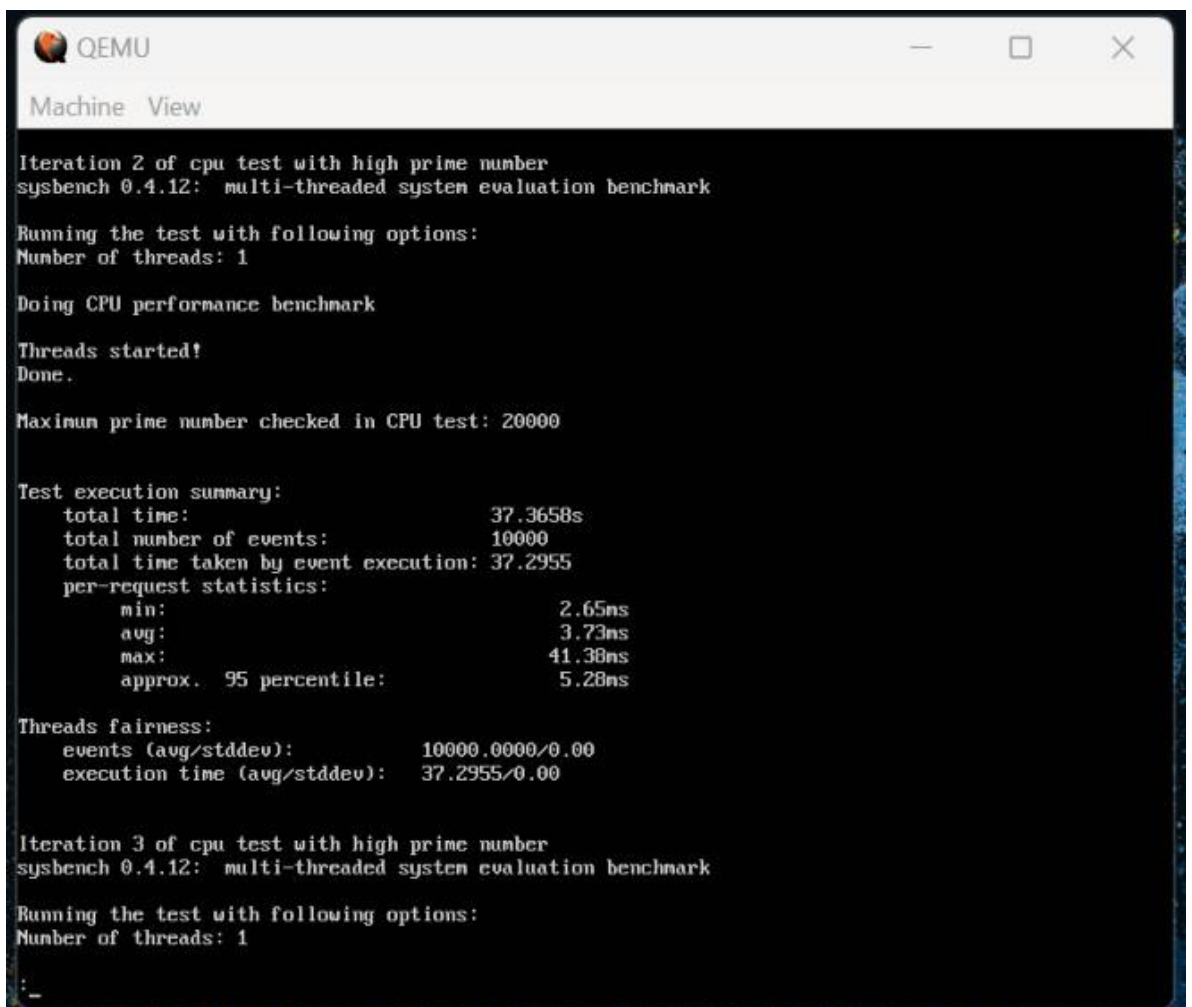
### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 7.11 ms     | 7.12 ms     | 7.48 ms     | 7.24 ms     | 7.65 ms     |
| Min. time taken                      | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     | 0.00 ms     |
| Total time taken for event execution | 1.9482      | 1.5277      | 1.6752      | 1.3455      | 1.6742      |

### QEMU- Qcow2 disk image:

### CPU Testing:

QEMU Qcow2 **CPU Testing** where Max-Prime = 20000 - test case 1



```
QEMU
Machine View

Iteration 2 of cpu test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
  total time:                37.3658s
  total number of events:    10000
  total time taken by event execution: 37.2955
  per-request statistics:
    min:                     2.65ns
    avg:                     3.73ns
    max:                     41.38ns
    approx. 95 percentile:   5.28ns

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 37.2955/0.00

Iteration 3 of cpu test with high prime number
sysbench 0.4.12: multi-threaded system evaluation benchmark

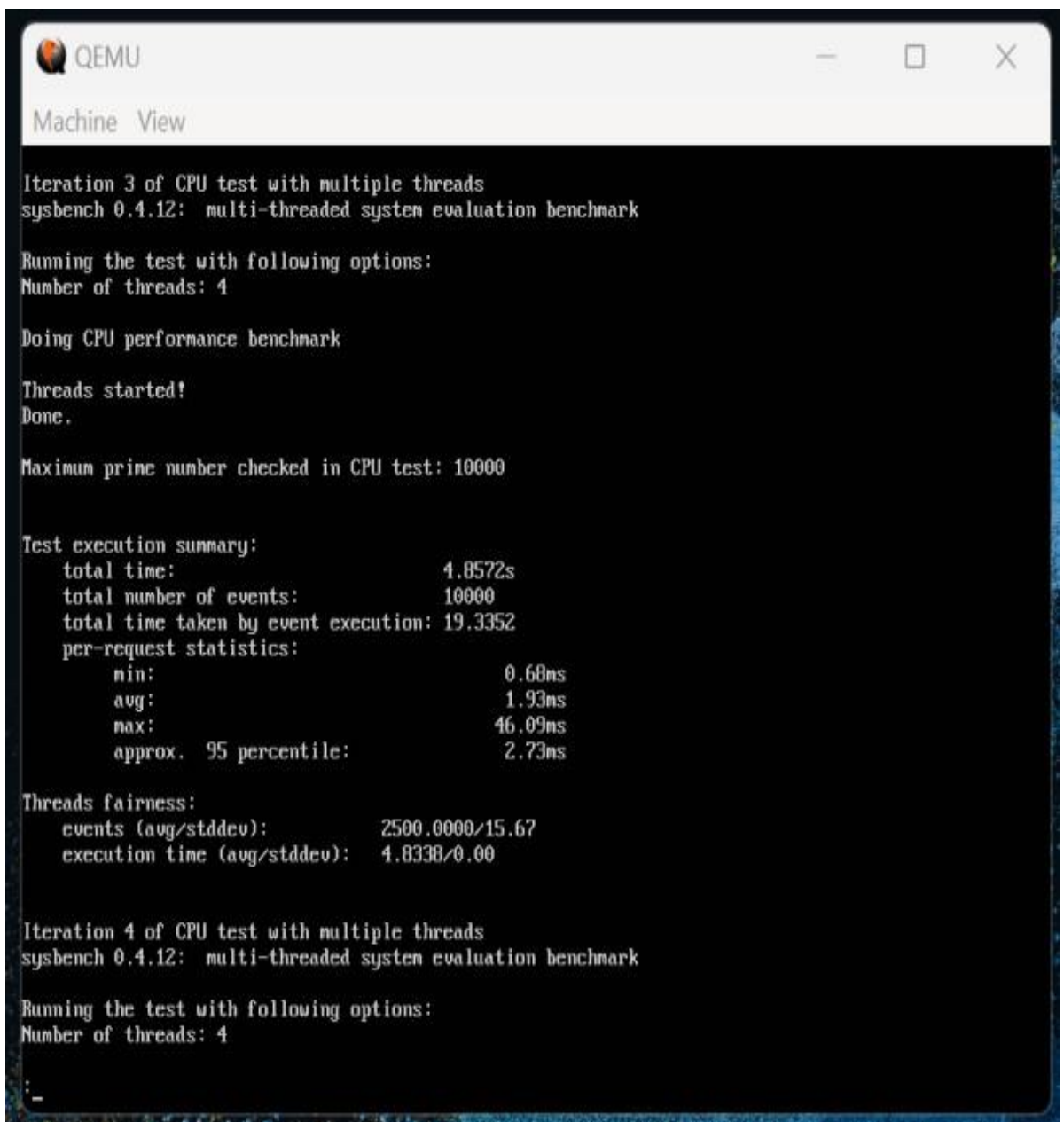
Running the test with following options:
Number of threads: 1

:_
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 2.65 ms     | 2.66 ms     | 2.69 ms     | 2.68 ms     | 2.67 ms     |
| Max. time taken                            | 41.38 ms    | 41.36 ms    | 41.32 ms    | 41.33 ms    | 41.39 ms    |
| Min. time taken                            | 2.65 ms     | 2.66 ms     | 2.68 ms     | 2.48 ms     | 2.58 ms     |
| Total time taken<br>for event<br>execution | 37.2955     | 37.8524     | 37.5548     | 37.2496     | 37.4589     |

QEMU Qcow2 CPU Testing where Max-Prime = 10000 - test case 2



```
QEMU
Machine View

Iteration 3 of CPU test with multiple threads
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
  total time:                4.8572s
  total number of events:    10000
  total time taken by event execution: 19.3352
  per-request statistics:
    min:                      0.68ns
    avg:                      1.93ns
    max:                      46.09ns
    approx. 95 percentile:    2.73ns

Threads fairness:
  events (avg/stddev):       2500.0000/15.67
  execution time (avg/stddev): 4.8338/0.00

Iteration 4 of CPU test with multiple threads
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

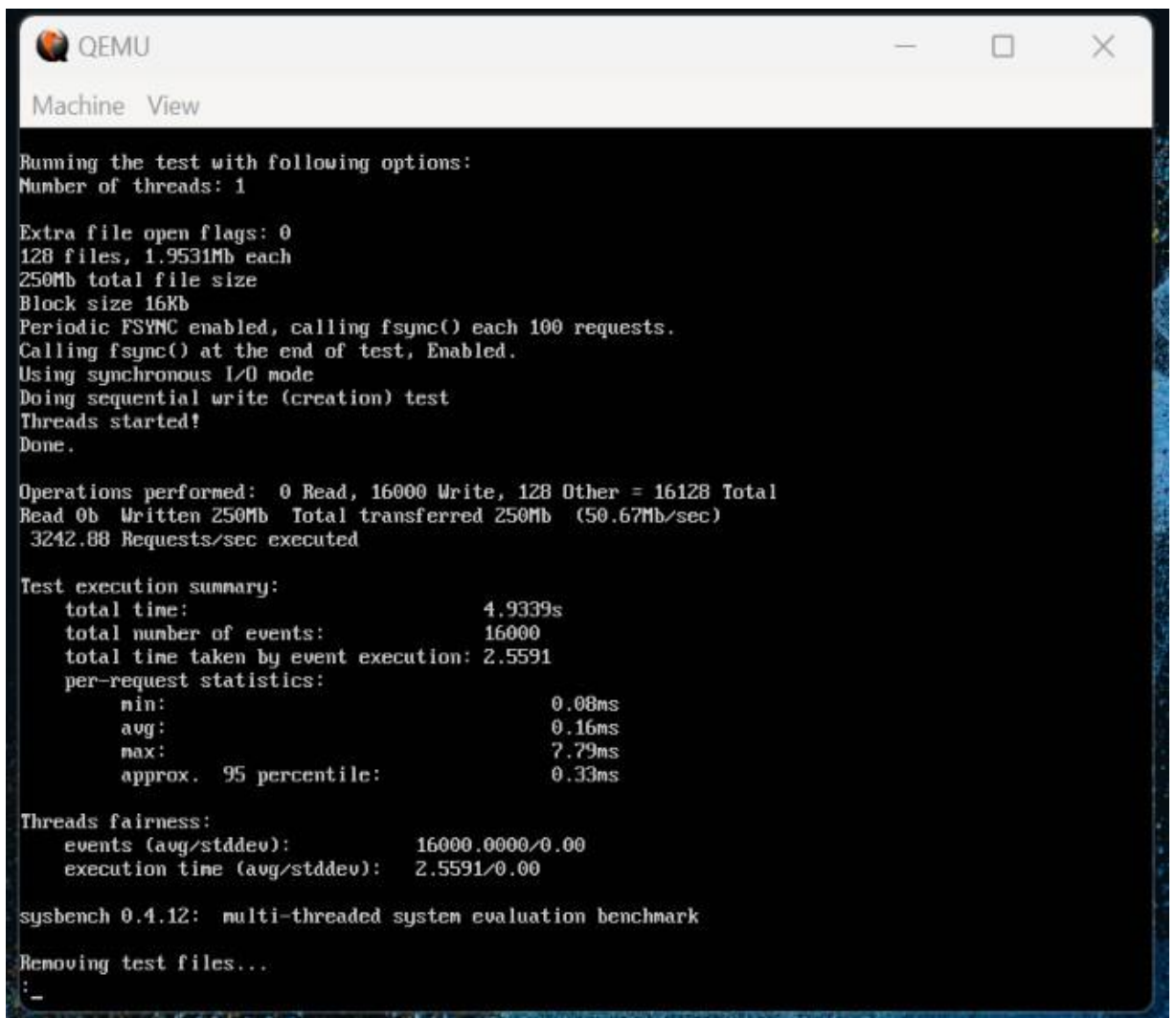
:_
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 1.93 ms     | 1.92 ms     | 1.91 ms     | 1.94 ms     | 1.98 ms     |
| Max. time taken                      | 46.38 ms    | 46.36 ms    | 46.32 ms    | 46.33 ms    | 46.39 ms    |
| Min. time taken                      | 0.60 ms     | 0.66 ms     | 0.68 ms     | 0.48 ms     | 0.58 ms     |
| Total time taken for event execution | 19.3352     | 19.3258     | 19.5548     | 19.2496     | 19.4589     |

### File I/O Testing:

QEMU qcow2 results for **File I/O Testing** for 4 GB RAM and 8 Core for Sequential Write

A screenshot of a QEMU terminal window. The window title is "QEMU" with standard window controls. The terminal output shows the configuration and results of a sysbench test. The test was run with 1 thread, 128 files of 1.9531Mb each, and a total file size of 250Mb. The block size was 16Kb. The test performed 16,000 write operations, transferring 250Mb at a rate of 50.67Mb/sec. The test execution summary shows a total time of 4.9339s, with 16,000 events and a total time taken by event execution of 2.5591s. Per-request statistics show a minimum of 0.08ms, an average of 0.16ms, a maximum of 7.79ms, and a 95th percentile of 0.33ms. The threads fairness section shows 16,000 events and an execution time of 2.5591s. The sysbench version is 0.4.12, and it is identified as a multi-threaded system evaluation benchmark. The terminal ends with "Removing test files..." and a prompt character.

```
QEMU
Machine View

Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (50.67Mb/sec)
3242.88 Requests/sec executed

Test execution summary:
total time: 4.9339s
total number of events: 16000
total time taken by event execution: 2.5591
per-request statistics:
  min: 0.08ms
  avg: 0.16ms
  max: 7.79ms
  approx. 95 percentile: 0.33ms

Threads fairness:
  events (avg/stddev): 16000.0000/0.00
  execution time (avg/stddev): 2.5591/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:_
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.16 ms     | 0.12 ms     | 0.11 ms     | 0.14 ms     | 0.18 ms     |
| Max. time taken                            | 7.79 ms     | 7.36 ms     | 7.32 ms     | 7.33 ms     | 7.39 ms     |
| Min. time taken                            | 0.08 ms     | 0.06 ms     | 0.08 ms     | 0.08 ms     | 0.08 ms     |
| Total time taken<br>for event<br>execution | 2.5591      | 2.3258      | 2.5548      | 2.2496      | 2.4589      |

QEMU qcow2 results for **File I/O Testing** for 4 GB RAM and 8 Core for Random Read

```
QEMU
Machine View
Number of threads: 1

Extra file open flags: 0
128 files, 2.3438Mb each
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (380Mb/sec)
24320.01 Requests/sec executed

Test execution summary:
total time: 0.4112s
total number of events: 10000
total time taken by event execution: 0.3738
per-request statistics:
  min: 0.02ns
  avg: 0.04ns
  max: 4.58ns
  approx. 95 percentile: 0.05ns

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 0.3738/0.00

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
:
```

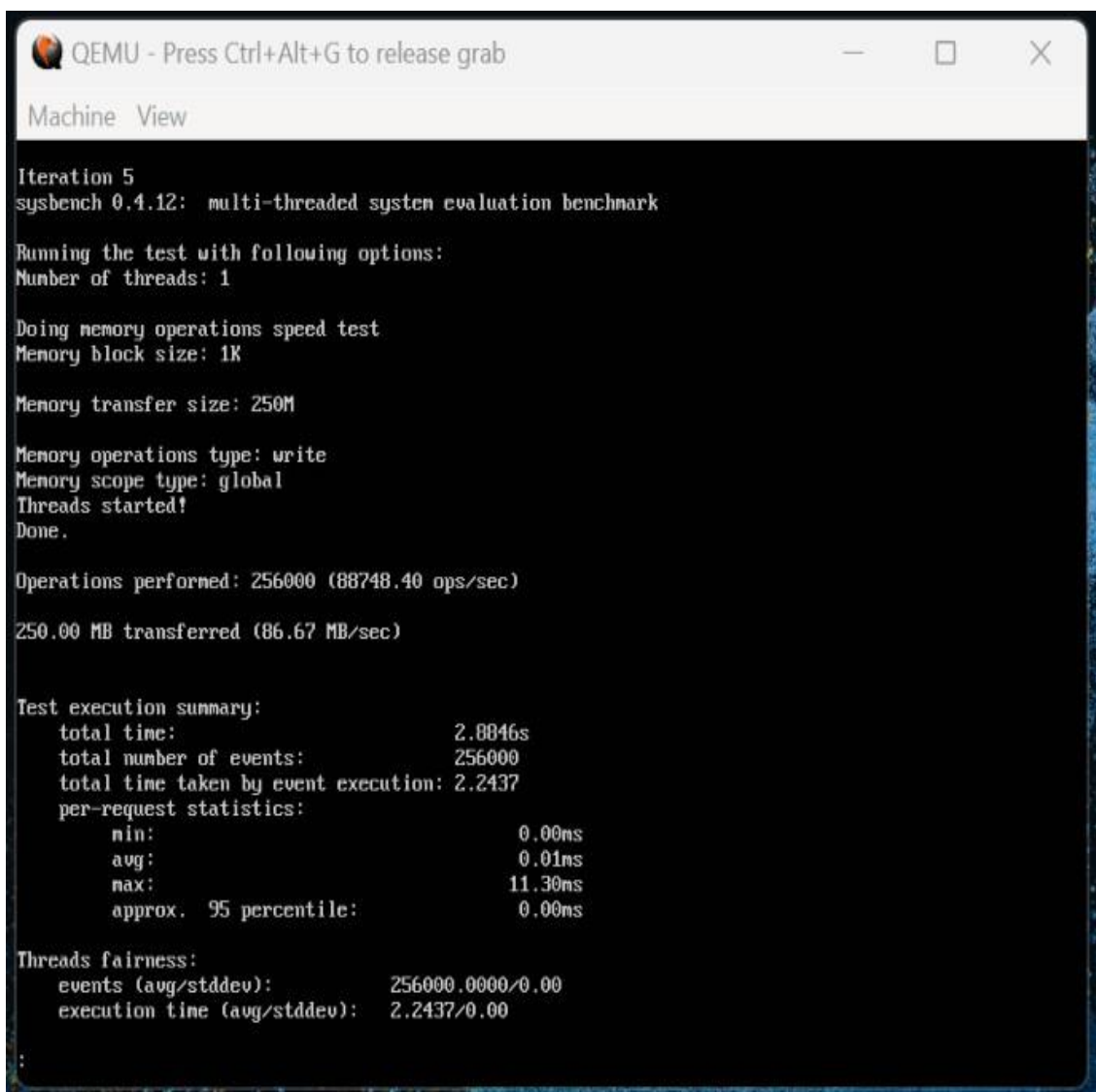


### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.04 ms     | 0.06 ms     | 0.03 ms     | 0.05 ms     | 0.05 ms     |
| Max. time taken                      | 4.58 ms     | 4.52 ms     | 4.53 ms     | 4.55 ms     | 4.58 ms     |
| Min. time taken                      | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     | 0.02 ms     |
| Total time taken for event execution | 0.3738      | 0.3258      | 0.5548      | 0.2496      | 0.4589      |

### Memory Testing:

QEMU qcow2 results for **Memory Testing** for 4GB RAM and 8 Core for Sequential Memory Access – Total memory size = 250 MB

A screenshot of a QEMU terminal window. The title bar reads "QEMU - Press Ctrl+Alt+G to release grab" with standard window controls. Below the title bar is a menu bar with "Machine" and "View". The terminal output shows the execution of sysbench 0.4.12, specifically the multi-threaded system evaluation benchmark. It details the configuration: 1 thread, memory operations speed test, 1K block size, 250M transfer size, write operations, global scope. The results show 256,000 operations performed at 88,748.40 ops/sec, with 250.00 MB transferred at 86.67 MB/sec. A test execution summary follows, showing a total time of 2.8046s, 256,000 events, and a total time taken by event execution of 2.2437s. Per-request statistics show a minimum of 0.00ms, an average of 0.01ms, a maximum of 11.30ms, and a 95th percentile of 0.00ms. Finally, thread fairness is reported with an average of 256,000.0000/0.00 events and an execution time of 2.2437/0.00.

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View

Iteration 5
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (88748.40 ops/sec)

250.00 MB transferred (86.67 MB/sec)

Test execution summary:
  total time:                2.8046s
  total number of events:     256000
  total time taken by event execution: 2.2437
  per-request statistics:
    min:                      0.00ms
    avg:                       0.01ms
    max:                       11.30ms
    approx. 95 percentile:    0.00ms

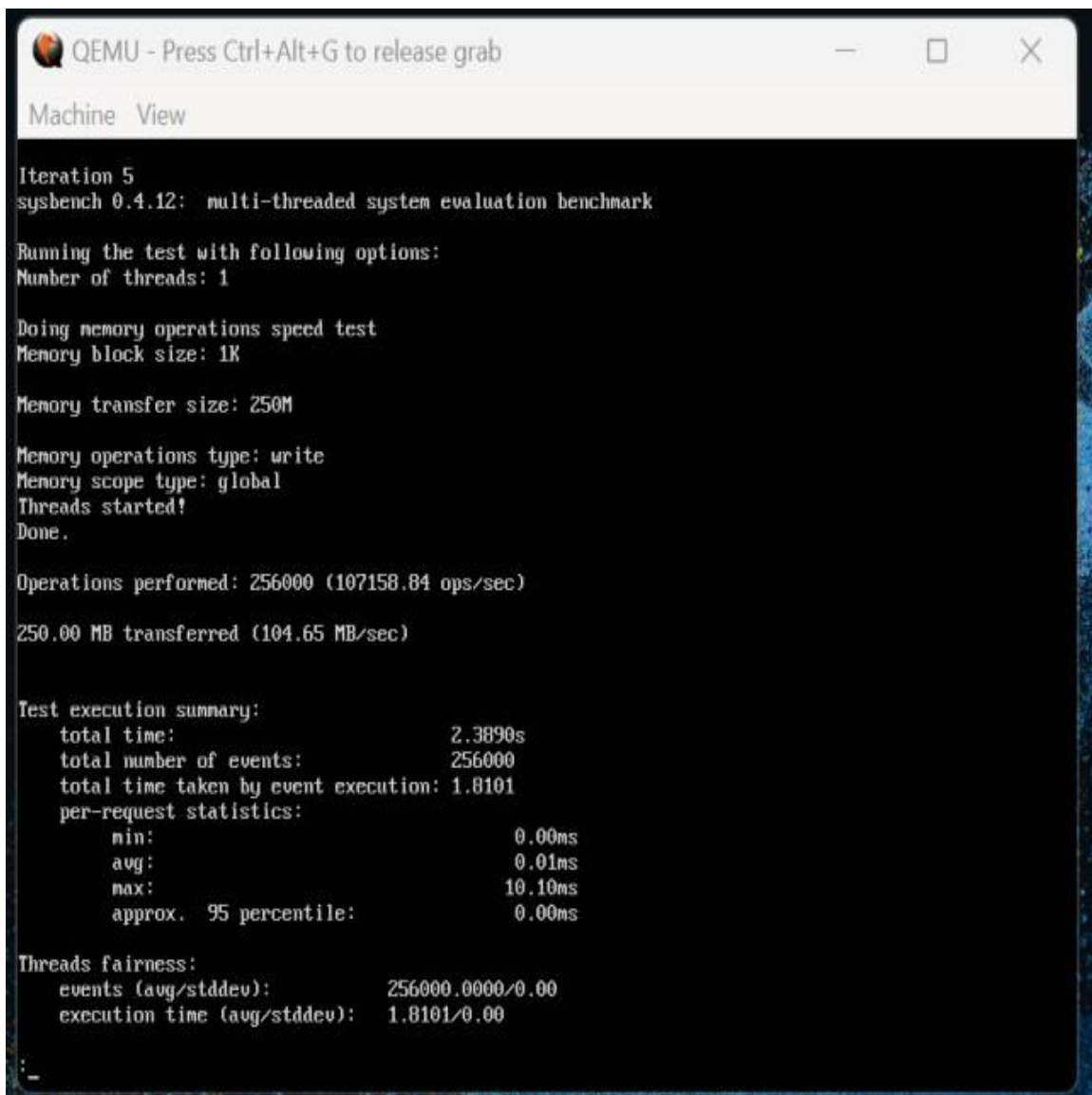
Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 2.2437/0.00
:
```



### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 11.30 ms    | 11.28 ms    | 11.36 ms    | 11.33 ms    | 11.38 ms    |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 2.2437      | 2.6658      | 2.5521      | 2.2816      | 2.2359      |

QEMU qcow2 results for **Memory Testing** for 4GB RAM and 8 Core for Random Memory Access – Total memory size = 250 MB

A screenshot of a QEMU terminal window. The title bar reads "QEMU - Press Ctrl+Alt+G to release grab". Below the title bar, the text "Machine View" is visible. The terminal output shows the results of a sysbench memory test. It starts with "Iteration 5" and "sysbench 0.4.12: multi-threaded system evaluation benchmark". It then lists the options: "Running the test with following options:", "Number of threads: 1", "Doing memory operations speed test", "Memory block size: 1K", "Memory transfer size: 250M", "Memory operations type: write", "Memory scope type: global", "Threads started!", and "Done.". The results show "Operations performed: 256000 (107158.84 ops/sec)" and "250.00 MB transferred (104.65 MB/sec)". A "Test execution summary:" section follows, showing "total time: 2.3890s", "total number of events: 256000", "total time taken by event execution: 1.8101", and "per-request statistics:" with "min: 0.00ms", "avg: 0.01ms", "max: 10.10ms", and "approx. 95 percentile: 0.00ms". Finally, a "Threads fairness:" section shows "events (avg/stddev): 256000.0000/0.00" and "execution time (avg/stddev): 1.8101/0.00".

```
QEMU - Press Ctrl+Alt+G to release grab
Machine View
Iteration 5
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K
Memory transfer size: 250M
Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (107158.84 ops/sec)
250.00 MB transferred (104.65 MB/sec)

Test execution summary:
  total time:                2.3890s
  total number of events:    256000
  total time taken by event execution: 1.8101
  per-request statistics:
    min:                      0.00ms
    avg:                      0.01ms
    max:                      10.10ms
    approx. 95 percentile:    0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 1.8101/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 10.10 ms    | 10.18 ms    | 10.09 ms    | 10.06 ms    | 10.08 ms    |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 1.8101      | 1.8523      | 1.8546      | 1.8752      | 1.8642      |

### Docker Results for 4 GB 8 Core:

#### CPU Testing:

Results for Docker based **CPU Testing** where Max-Prime = 20000 - test case 1

```
C:\Users\Nityanand Pujari>docker run -it -m 4g --cpus=8 ubuntu37
root@af2ce3a7ea8b:/# chmod +x cpu_bash_script.sh
root@af2ce3a7ea8b:/# ./cpu_bash_script.sh
Running First CPU Test: High Prime Number Calculation
Iteration 1
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 20000

Test execution summary:
total time: 13.2565s
total number of events: 10000
total time taken by event execution: 13.2537
per-request statistics:
  min: 1.16ms
  avg: 1.33ms
  max: 11.71ms
  approx. 95 percentile: 1.72ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 13.2537/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 1.33 ms     | 1.38 ms     | 1.36 ms     | 1.35 ms     | 1.45 ms     |
| Max. time taken                      | 11.71 ms    | 11.12 ms    | 11.48 ms    | 11.24 ms    | 11.65 ms    |
| Min. time taken                      | 1.16 ms     | 1.25 ms     | 1.18 ms     | 1.21 ms     | 1.25 ms     |
| Total time taken for event execution | 13.2537     | 13.5277     | 13.6752     | 13.3455     | 13.6742     |

Results for Docker based **CPU Testing** where Max-Prime = 10000 - test case 2

```
Iteration 3
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 4

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 10000

Test execution summary:
  total time:                1.9028s
  total number of events:    10000
  total time taken by event execution: 7.6065
  per-request statistics:
    min:                     0.46ms
    avg:                     0.76ms
    max:                     0.75ms
    approx. 95 percentile:   0.99ms

Threads fairness:
  events (avg/stddev):       2500.0000/54.67
  execution time (avg/stddev): 1.9016/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.76 ms     | 0.78 ms     | 0.76 ms     | 0.75 ms     | 0.75 ms     |
| Max. time taken                      | 8.75 ms     | 8.12 ms     | 8.48 ms     | 8.24 ms     | 8.65 ms     |
| Min. time taken                      | 0.46 ms     | 0.25 ms     | 0.18 ms     | 0.21 ms     | 0.25 ms     |
| Total time taken for event execution | 7.6065      | 13.5277     | 13.6752     | 13.3455     | 13.6742     |

### File I/O Testing:

Docker results for **File I/O Testing** for 4 GB RAM and 8 Core for Sequential Write

```
Running the test with following options:
Number of threads: 1

Extra file open flags: 0
128 files, 1.9531Mb each
250Mb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 16000 Write, 128 Other = 16128 Total
Read 0b Written 250Mb Total transferred 250Mb (418.99Mb/sec)
26815.27 Requests/sec executed

Test execution summary:
  total time:                0.5967s
  total number of events:    16000
  total time taken by event execution: 0.1680
  per-request statistics:
    min:                     0.01ms
    avg:                     0.01ms
    max:                     0.81ms
    approx. 95 percentile:   0.01ms

Threads fairness:
  events (avg/stddev):       16000.0000/0.00
  execution time (avg/stddev): 0.1680/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.81 ms     | 0.12 ms     | 0.48 ms     | 0.24 ms     | 0.65 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 0.1680      | 0.5277      | 0.6752      | 0.3455      | 0.6742      |

Docker results for **File I/O Testing** for 4 GB RAM and 8 Core for Random Read

```
Number of threads: 1

Extra file open flags: 0
128 files, 2.3438Mb each
300Mb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (3.0579Gb/sec)
200404.11 Requests/sec executed

Test execution summary:
  total time:                0.0499s
  total number of events:    10000
  total time taken by event execution: 0.0476
  per-request statistics:
    min:                     0.00ms
    avg:                     0.00ms
    max:                     0.57ms
    approx. 95 percentile:   0.01ms

Threads fairness:
  events (avg/stddev):       10000.0000/0.00
  execution time (avg/stddev): 0.0476/0.00
```

### Test Execution Summary:

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                            | 8.57 ms     | 8.52 ms     | 8.48 ms     | 8.54 ms     | 8.55 ms     |
| Min. time taken                            | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken<br>for event<br>execution | 0.0476      | 0.0277      | 0.0752      | 0.0455      | 0.0742      |

### Memory Testing:

Docker results for **Memory Testing** for 4GB RAM and 8 Core for Sequential Memory Access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (2995276.73 ops/sec)

250.00 MB transferred (2925.07 MB/sec)

Test execution summary:
  total time:                0.0855s
  total number of events:    256000
  total time taken by event execution: 0.0687
  per-request statistics:
    min:                     0.00ms
    avg:                     0.00ms
    max:                     0.75ms
    approx. 95 percentile:   0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0687/0.00
```

### Test Execution Summary:

|                                      | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                              | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                      | 0.75 ms     | 0.76 ms     | 0.77 ms     | 0.76 ms     | 0.78 ms     |
| Min. time taken                      | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken for event execution | 0.0687      | 0.0677      | 0.0652      | 0.0655      | 0.0642      |

Docker results for **Memory Testing** for 4GB RAM and 8 Core for Random Memory Access – Total memory size = 250 MB

```
Running the test with following options:
Number of threads: 1

Doing memory operations speed test
Memory block size: 1K

Memory transfer size: 250M

Memory operations type: write
Memory scope type: global
Threads started!
Done.

Operations performed: 256000 (3480164.79 ops/sec)

250.00 MB transferred (3398.60 MB/sec)

Test execution summary:
  total time:                0.0736s
  total number of events:    256000
  total time taken by event execution: 0.0577
  per-request statistics:
    min:                      0.00ms
    avg:                      0.00ms
    max:                      0.67ms
    approx. 95 percentile:    0.00ms

Threads fairness:
  events (avg/stddev):       256000.0000/0.00
  execution time (avg/stddev): 0.0577/0.00
```

### **Test Execution Summary:**

|                                            | Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|--------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Average                                    | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Max. time taken                            | 0.67 ms     | 0.66 ms     | 0.67 ms     | 0.66 ms     | 0.68 ms     |
| Min. time taken                            | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     | 0.01 ms     |
| Total time taken<br>for event<br>execution | 0.0577      | 0.0587      | 0.0542      | 0.0564      | 0.0538      |

### **Experiment Analysis:**

- Sysbench was used to assess the effects on performance by setting virtual machines (VMs) and containers with different numbers of CPU cores and RAM.
- Performance measures such memory bandwidth, file I/O operations, and CPU processing power were assessed.
- There is a direct relationship between system performance and the quantity of resources allocated; more resources result in improved performance metrics in Docker containers as well as QEMU virtual machines.
- In contrast, with equal resource allocations, Docker containers typically demonstrated superior resource consumption and performance efficiency over QEMU virtual machines.
- Docker's enhanced processing capabilities are demonstrated by its superior efficiency with noticeably shorter execution times in CPU testing.
- Memory performance tests show even more how well Docker manages and uses system memory, with lower latency and faster access times.
- Docker highlights its sophisticated disk management capabilities by demonstrating improved throughput and decreased latency for disk I/O operations in both sequential and random read/write jobs.
- Docker's ability to give superior performance metrics is clearly demonstrated by the analysis, which makes it a great platform for deploying apps that require high efficiency and quick response times.
- Its benefits over QEMU are greatest in settings where performance and resource optimization are important factors.

### **Conclusion:**

- The experiment unequivocally shows that workloads that do not require the complete isolation and hardware emulation offered by QEMU VMs may be handled more effectively with Docker containers.



- Docker containers are the recommended option for applications where resource efficiency and performance are critical factors.
- QEMU virtual machines, however, are still applicable in situations when total isolation and hardware environment simulation are necessary.
- The scalability of these results across more varied workloads and larger-scale deployments could be investigated in future research to better understand the trade-offs between virtualization and containerization.
- The main ideas of your paper are summarized in this summary, which also highlights the experimental results and their implications for the selection of virtualization vs containerization technologies for various use cases.

## **Extra Credit-**

### **Docker File:**

```
FROM Aditya/ubuntu:16.04

COPY test-docker.sh /test-docker.sh
COPY cpu-tests.sh /cpu-tests.sh
COPY test-File-io.sh /test-File-io.sh
COPY test-Memory.sh /test-Memory.sh

RUN chmod +x test-docker.sh
RUN chmod +x cpu-tests.sh
RUN chmod +x test-File-io.sh
RUN chmod +x test-Memory.sh

ENTRYPOINT ["bash", "test-docker.sh"]
```

---

### **Vagrant File:**

```
Vagrant.configure("2") do |config|
  config.vm.box = "ubuntu/bionic64"

  # Configure a private network
  config.vm.network "private_network", type: "dhcp"

  # Customize the VirtualBox provider settings
  config.vm.provider "virtualbox" do |vb|
    vb.memory = "4024" # Allocate 4 GB of memory
    vb.cpus = 4         # Allocate 4 CPU cores
  end
end
```