

CSEN241 Cloud Computing: Homework 1

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System Configuration

Chip	Apple M3
CPU	8 (4 performance and 4 efficiency)
Memory	8 GB
Free Disk Space	40.23 GB of 245.11 GB
Operating System	Mac OS X

Qemu Installation and Creation of Disk Image

```
Last login: Fri Feb  2 23:36:57 on ttys001
(base) nikhilshankar@Incharas-iMac ~ % arch
arm64
(base) nikhilshankar@Incharas-iMac ~ %
```

Download Ubuntu ISO Image based on the device's architecture

ARM (Apple Silicon) <https://docs.docker.com/desktop/mac/apple-silicon/>

```
(base) nikhilshankar@Incharas-iMac ~ % cd
(base) nikhilshankar@Incharas-iMac ~ % ls *.iso
ubuntu-20.04.5-live-server-arm64.iso
(base) nikhilshankar@Incharas-iMac ~ %
```

Install QEMU

``brew install qemu``

```
((base) nikhilshankar@Incharas-iMac ~ % brew install qemu
Running `brew update --auto-update`...
Installing from the API is now the default behaviour!
You can save space and time by running:
  brew untap homebrew/core
==> Auto-updated Homebrew!
Updated 2 taps (homebrew/core and homebrew/cask).
==> New Formulae
sui
==> New Casks
lunarbar

You have 8 outdated formulae installed.

Warning: qemu 8.2.1 is already installed and up-to-date.
To reinstall 8.2.1, run:
  brew reinstall qemu
(base) nikhilshankar@Incharas-iMac ~ %
```

Check QEMU Version

```
((base) nikhilshankar@Incharas-iMac ~ % qemu-system-x86_64 --version
QEMU emulator version 8.2.1
Copyright (c) 2003-2023 Fabrice Bellard and the QEMU Project developers
(base) nikhilshankar@Incharas-iMac ~ %
```

Create QEMU Image

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

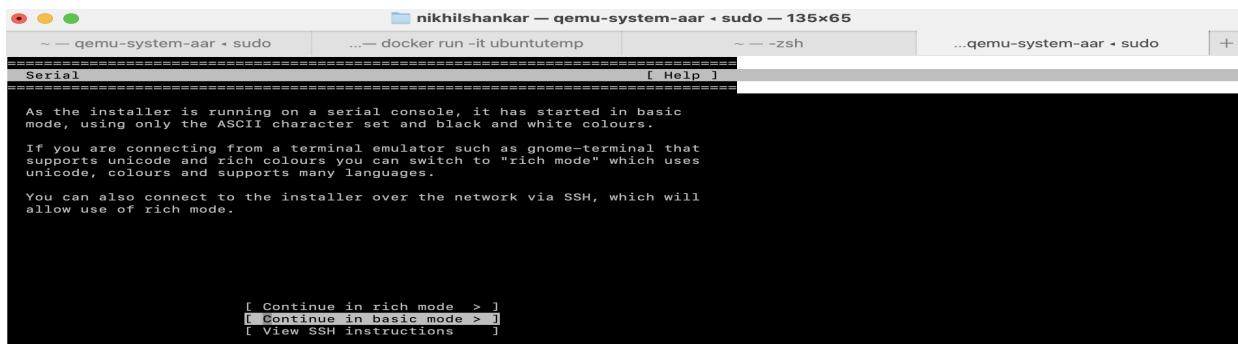
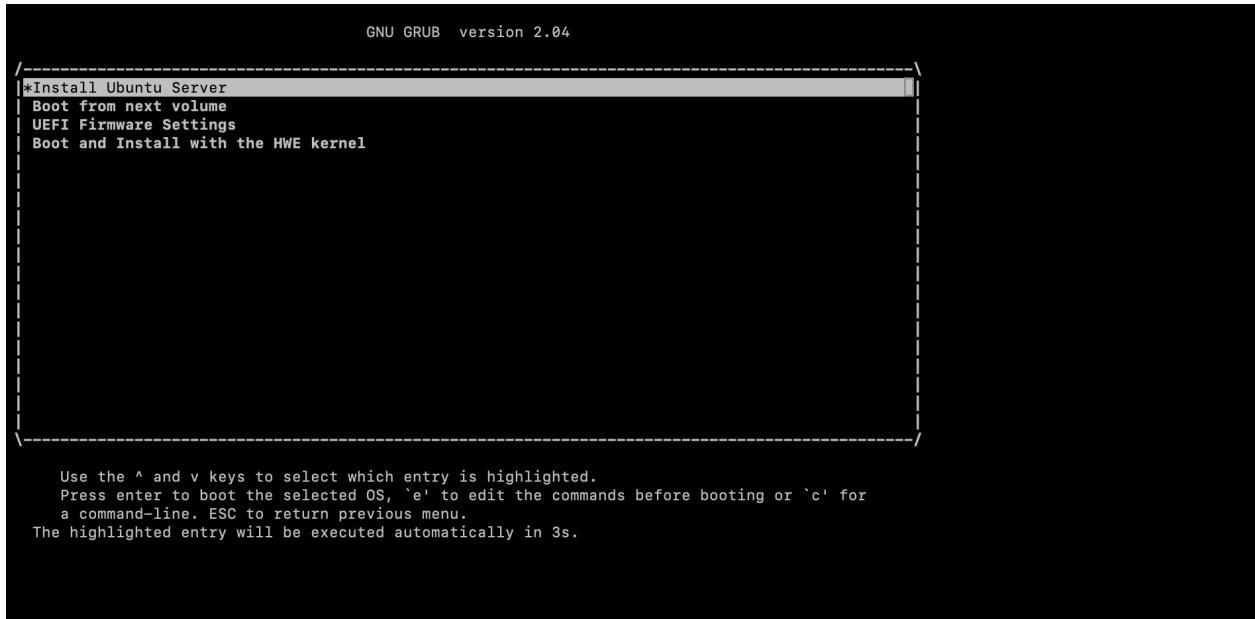
```
((base) nikhilshankar@Incharas-iMac ~ % qemu-img create ubuntu.img 10G -f qcow2
Formatting 'ubuntu.img', fmt=qcow2 cluster_size=65536 extended_l2=off compression=zlib size=10737418240 lazy_refcounts=off refcount_bits=16
(base) nikhilshankar@Incharas-iMac ~ % ls
Applications           Sites
Desktop                anaconda3
Documents              iCloud Drive (Archive)
Downloads              iCloud Drive (Archive) - 1
Google Drive            node_modules
Library                 package-lock.json
Movies                  package.json
Music                  ubuntu-20.04.5-live-server-arm64.iso
Pictures               ubuntu.img
Postman                 ubuntu_qcow2.img
Public                 ubuntu_raw.img
(base) nikhilshankar@Incharas-iMac ~ % ls *.img
ubuntu.img          ubuntu_qcow2.img      ubuntu_raw.img
(base) nikhilshankar@Incharas-iMac ~ %
```

Install Ubuntu VM

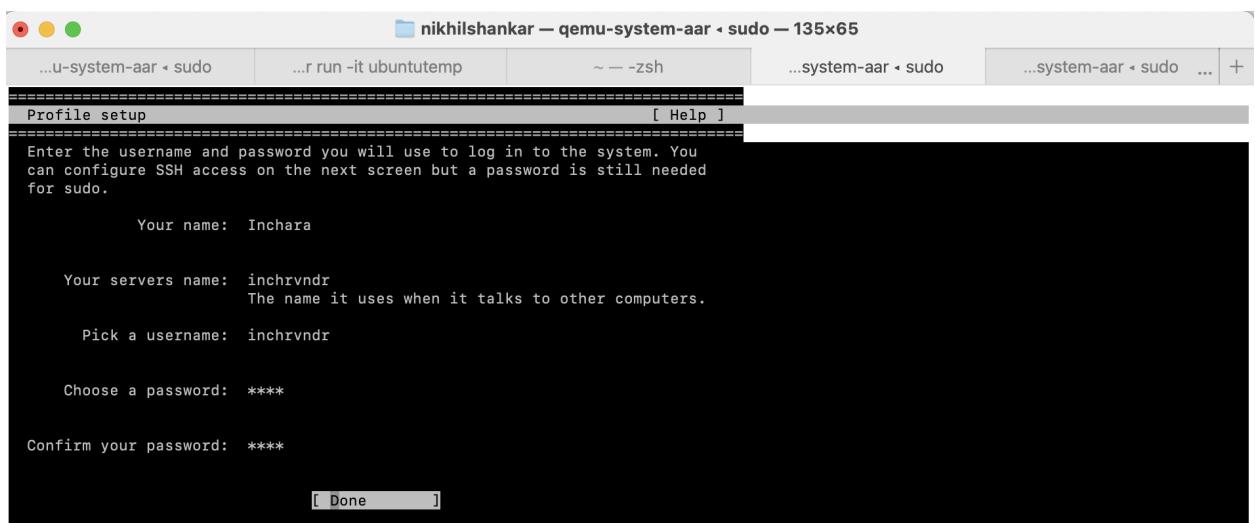
```
``sudo qemu-system-aarch64 -accel hvf -cpu cortex-a57 -M virt,highmem=off -m 2048 -smp 2
-drive
file=/opt/homebrew/Cellar/qemu/8.2.1/share/qemu/edk2-aarch64-code.fd,if=pflash,format=raw,readonly=on -drive if=none,file=ubuntu_qcow2.img,format=qcow2,id=hd0 -device virtio-blk-device,drive=hd0,serial="dummyserial" -device virtio-net-device,netdev=net0
-netdev user,id=net0 -vga none -device ramfb -cdrom ubuntu-20.04.5-live-server-arm64.iso
-device usb-ehci -device usb-kbd -device usb-mouse -usb -nographic``
```

Follow the installation instructions

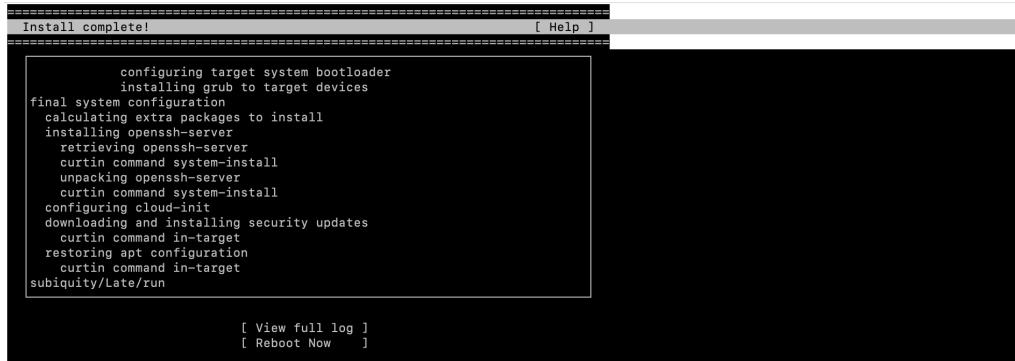
```
((base) nikhilshankar@Incharas-iMac ~ % sudo qemu-system-aarch64 -accel hvf -cpu cortex-a57 -M virt,highmem=off -m 2048 -smp 2 -drive file=/opt/homebrew/Cellar/qemu/8.2.1/share/qemu/edk2-aarch64-code.fd,if=pflash,format=raw,readonly=on -drive if=none,file=ubuntu_qcow2.img,format=qcow2,id=hd0 -device virtio-blk-device,drive=hd0,serial="dummyserial" -device virtio-net-device,netdev=net0 -netdev user,id=net0 -vga none -device ramfb -cdrom ubuntu-20.04.5-live-server-arm64.iso -device usb-ehci -device usb-kbd -device usb-mouse -usb -no graphic
UEFI firmware (version edk2-stable202302-for-qemu built at 09:21:28 on Dec 13 2023)
Error: Image at 000BFC7F000 start failed: Unsupported
Error: Image at 000BF8FF000 start failed: Not Found
Tpm2SubmitCommand - Tcg2 - Not Found
Tpm2GetCapabilityPcrs fail!
Tpm2SubmitCommand - Tcg2 - Not Found
```



Set up profile and login details



Select reboot option



To login to the installed VM use the following command i.e, same as previous one but without cdrom option

```
``sudo qemu-system-aarch64 -accel hvf -cpu cortex-a57 -M virt,highmem=off -m 2048 -smp 2
-drive
file=/opt/homebrew/Cellar/qemu/8.2.1/share/qemu/edk2-aarch64-code.fd,if=pflash,format=raw,r
eadonly=on -drive if=none,file=ubuntu_qcow2.img,format=qcow2,id=hd0 -device
virtio-blk-device,drive=hd0,serial="dummyserial" -device virtio-net-device,netdev=net0
-netdev user,id=net0 -vga none -device ramfb -device usb-ehci -device usb-kbd -device
usb-mouse -usb -nographic``
```

The terminal window title is "nikhilshankar — qemu-system-aar • sudo — 80x24". The log shows the following system bootup steps:

```
[ OK ] Started Snap Daemon.
      Starting Wait until snapd is fully seeded...
      Starting Time & Date Service...
[ OK ] Started Time & Date Service.
[ OK ] Finished Wait until snapd is fully seeded.
      Starting Apply the settings specified in cloud-config...
[ OK ] Finished Service for snap application lxd.activate.
[ 7.391549] cloud-init[868]: Cloud-init v. 23.1.2-0ubuntu0~20.04.2 running 'n
odules:config' at Sat, 03 Feb 2024 20:57:40 +0000. Up 7.35 seconds.
[ OK ] Finished Apply the settings specified in cloud-config.
[ OK ] Reached target Multi-User System.
[ OK ] Reached target Graphical Interface.
      Starting Execute cloud user/final scripts...
      Starting Update UTMP about System Runlevel Changes...
[ OK ] Finished Update UTMP about System Runlevel Changes.
[ 7.584697] cloud-init[874]: Cloud-init v. 23.1.2-0ubuntu0~20.04.2 running 'n
odules:final' at Sat, 03 Feb 2024 20:57:40 +0000. Up 7.54 seconds.
[ 7.585200] cloud-init[874]: Cloud-init v. 23.1.2-0ubuntu0~20.04.2 finished a
t Sat, 03 Feb 2024 20:57:40 +0000. Datasource DataSourceNone. Up 7.58 seconds
[ 7.585575] cloud-init[874]: 2024-02-03 20:57:40,675 - cc_final_message.py[W/
RNING]: Used fallback datasource
[ OK ] Finished Execute cloud user/final scripts.
[ OK ] Reached target Cloud-init target.
```

```
t Sat, 03 Feb 2024 20:57:40 +0000. Datasource DataSourceNone. Up 7.58 seconds
[    7.585575] cloud-init[874]: 2024-02-03 20:57:40,675 - cc_final_message.py[W]
RNING]: Used fallback datasource
[ OK ] Finished Execute cloud user/final scripts.
[ OK ] Reached target Cloud-init target.
```

```
Ubuntu 20.04.5 LTS inchrnvndr ttyAMA0
```

```
[inchrnvndr login: inchrnvndr
Password: █
```

```
* Support: https://ubuntu.com/advantage
```

```
System information as of Sat Feb 3 20:58:06 UTC 2024
```

```
System load: 0.05
Usage of /: 51.1% of 7.50GB
Memory usage: 10%
Swap usage: 0%
Processes: 118
Users logged in: 0
IPv4 address for eth0: 10.0.2.15
IPv6 address for eth0: fec0::5054:ff:fe12:3456
```

```
* Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
just raised the bar for easy, resilient and secure K8s cluster deployment.
```

```
https://ubuntu.com/engage/secure-kubernetes-at-the-edge
```

```
66 updates can be applied immediately.
```

```
To see these additional updates run: apt list --upgradable
```

```
Last login: Sat Feb 3 02:58:48 UTC 2024 on ttyAMA0
inchrnvndr@inchrnvndr:~$ █
```

Explanation for all options used in the previous command

-accel hvf	Specifies the hardware virtualization framework to use. In this case, it's using hvf (Hypervisor.framework) for acceleration.
-cpu cortex-a57	Emulate the Cortex-A57 CPU architecture. This option specifies the CPU model to emulate.
-M virt,highmem=off	Emulate a virtual machine with the "virt" machine type. The highmem=off option disables high memory support.
-m 2048	Set the amount of RAM for the virtual machine to 2048 MB (2 GB).
-smp 2	Set the number of virtual CPUs (cores) to 2.
-drive	Attach a firmware image to the virtual

file=/opt/homebrew/Cellar/qemu/8.2.1/share/qemu/edk2-aarch64-code.fd,if=pflash,format=rw,readonly=on	machine. The firmware file (edk2-aarch64-code.fd) is used for UEFI booting.
-drive if=none,file=ubuntu_qcow2.img,format=qcow2,id=hd0	Define a virtual drive for the virtual machine. The QEMU instance will use the ubuntu_qcow2.img file as a virtual hard disk in QCOW2 format.
-device virtio-blk-device,drive=hd0,serial="dummyserial"	Add a virtual block device to the virtual machine. It is associated with the previously defined hard disk (hd0).
-device virtio-net-device,netdev=net0	Add a virtual network device to the virtual machine. It is associated with the network device named net0.
-netdev user,id=net0	Define a user-mode network stack. It allows the virtual machine to connect to the host system and the internet using NAT.
-vga none	Disable the VGA graphics adapter.
-device ramfb	Add a simple RAM framebuffer device.
-device usb-ehci -device usb-kbd -device usb-mouse -usb	Emulate USB devices for keyboard and mouse. This line sets up USB emulation with EHCI (Enhanced Host Controller Interface) support.
-nographic	Disable graphical output and run the QEMU instance in a terminal without a graphical window.
-cdrom	This option tells QEMU that the following argument specifies the path to the CD-ROM or ISO image that should be used.

Note: Adjustments to the -m (memory) and -smp (number of virtual CPUs) values will be made when running for different configurations.

Docker Setup: Installation, Image Creation, and Enabling Docker Container

In this section, we will go through the steps to install Docker, a platform used for creating and managing containers. Containers, in turn, allow the execution and management of various

images.

Follow the installation steps outlined in the official Docker documentation for Apple Silicon:

[Docker Desktop Installation for Apple Silicon](#)

By following the provided link, you will install Docker Desktop, which includes both the Docker CLI and Docker Engine. To verify the successful installation of Docker, execute the following commands in the terminal:

```
``docker pull hello-world:latest``  
``docker images``  
``docker run hello-world``
```



The screenshot shows a terminal window with two tabs. The left tab is titled 'qemu-system-aar < sudo' and the right tab is titled '-zsh'. The '-zsh' tab contains the following text:

```
Last login: Sat Feb 3 12:57:19 on ttys000  
[(base) nikhilshankar@Incharas-iMac ~ % docker pull hello-world:latest  
latest: Pulling from library/hello-world  
Digest: sha256:4bd7811b6914a99dbc560e6a20eab57ff6655aea4a80c50b0c5491968cbc2e6  
Status: Image is up to date for hello-world:latest  
docker.io/library/hello-world:latest  
[(base) nikhilshankar@Incharas-iMac ~ % docker images  
REPOSITORY TAG IMAGE ID CREATED SIZE  
updated-base-image latest ceba80a88288 13 hours ago 119MB  
updated-base-image mem3cpu2 82a39ab097d3 14 hours ago 119MB  
updated-base-image mem2cpu3 fcf8f94903ff 14 hours ago 119MB  
updated-base-image mem2cpu2 d60f5353131a 14 hours ago 119MB  
base-image mem3cpu3 7703ac014605 16 hours ago 119MB  
base-image mem3cpu2 5751b22f0ffe 16 hours ago 119MB  
base-image mem2cpu3 c3aca48aa0d1 16 hours ago 119MB  
base-image mem2cpu2 745d2ecdcd8 16 hours ago 119MB  
base-image latest 3e734bae3aea 17 hours ago 119MB  
ubuntu latest 9cbdd1f76112 9 days ago 69.2MB  
ubuntu 20.04 f8b1498b9544 11 days ago 65.7MB  
inchrvndr/collaborative-playlists latest d02ca9f16191 2 months ago 520MB  
frontend-image latest d02ca9f16191 2 months ago 520MB  
backend-server-1-image latest 10ce80dc9fc4 2 months ago 167MB  
inchrvndr/collaborative-playlists <none> 10ce80dc9fc4 2 months ago 167MB  
backend-server-2-image latest 44956d6c4367 2 months ago 167MB  
inchrvndr/collaborative-playlists <none> 44956d6c4367 2 months ago 167MB  
hello-world latest ee301c921b8a 9 months ago 9.14kB  
[(base) nikhilshankar@Incharas-iMac ~ % docker run hello-world  
  
Hello from Docker!  
This message shows that your installation appears to be working correctly.  
  
To generate this message, Docker took the following steps:  
1. The Docker client contacted the Docker daemon.  
2. The Docker daemon pulled the "hello-world" image from the Docker Hub.  
(arm64v8)  
3. The Docker daemon created a new container from that image which runs the executable that produces the output you are currently reading.  
4. The Docker daemon streamed that output to the Docker client, which sent it to your terminal.  
  
To try something more ambitious, you can run an Ubuntu container with:  
$ docker run -it ubuntu bash  
  
Share images, automate workflows, and more with a free Docker ID:  
https://hub.docker.com/  
  
For more examples and ideas, visit:  
https://docs.docker.com/get-started/  
(base) nikhilshankar@Incharas-iMac ~ %
```

```
``sudo docker run -it ubuntu:20.04``
``apt update``
``apt install <package>``
``apt install vim``
``apt install sysbench``
```

In another terminal tab:

```
``docker ps``
``docker commit <container_id> <image_name> docker images``
``docker history <image_name>``

[(base) nikhilshankar@Incharas-iMac ~ % sudo docker run -it ubuntu:20.04
[Password:
root@36ec46a5cf6d:/# █

root@36ec46a5cf6d:/# apt update
Get:1 http://ports.ubuntu.com/ubuntu-ports focal InRelease [265 kB]
Get:2 http://ports.ubuntu.com/ubuntu-ports focal-updates InRelease [114 kB]
Get:3 http://ports.ubuntu.com/ubuntu-ports focal-backports InRelease [108 kB]
Get:4 http://ports.ubuntu.com/ubuntu-ports focal-security InRelease [114 kB]
Get:5 http://ports.ubuntu.com/ubuntu-ports focal/main arm64 Packages [1234 kB]
Get:6 http://ports.ubuntu.com/ubuntu-ports focal/restricted arm64 Packages [1317 B]
Get:7 http://ports.ubuntu.com/ubuntu-ports focal/multiverse arm64 Packages [139 kB]
Get:8 http://ports.ubuntu.com/ubuntu-ports focal/universe arm64 Packages [11.1 MB]
Get:9 http://ports.ubuntu.com/ubuntu-ports focal-updates/multiverse arm64 Packages [9696 B]
Get:10 http://ports.ubuntu.com/ubuntu-ports focal-updates/restricted arm64 Packages [50.9 kB]
]
Get:11 http://ports.ubuntu.com/ubuntu-ports focal-updates/universe arm64 Packages [1365 kB]
Get:12 http://ports.ubuntu.com/ubuntu-ports focal-updates/main arm64 Packages [2882 kB]
Get:13 http://ports.ubuntu.com/ubuntu-ports focal-backports/universe arm64 Packages [27.8 kB]
]
Get:14 http://ports.ubuntu.com/ubuntu-ports focal-backports/main arm64 Packages [54.8 kB]
Get:15 http://ports.ubuntu.com/ubuntu-ports focal-security/main arm64 Packages [2497 kB]
Get:16 http://ports.ubuntu.com/ubuntu-ports focal-security/universe arm64 Packages [1069 kB]
Get:17 http://ports.ubuntu.com/ubuntu-ports focal-security/restricted arm64 Packages [50.7 kB]
]
Get:18 http://ports.ubuntu.com/ubuntu-ports focal-security/multiverse arm64 Packages [3615 B
]

[root@36ec46a5cf6d:/# apt install vim
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
alsa-topology-conf alsamixer alsound2 libasound2-data libcanberra0 libexpat1
libgpmm2 libltdl7 libmagic-mgc libmagic1 libmpdec2 libogg0 libpython3.8
libpython3.8-minimal libpython3.8-stdlib libreadline8 libsqlite3-0 libssl1.1 libtdb1
libvorbis0a libvorbisfile3 mime-support readline-common sound-theme-freedesktop
vim-common vim-runtime xxd xz-utils
Suggested packages:
alsa-plugins alsound2 libcanberra-gtk0 libcanberra-pulse gpm readline-doc ctags
vim-doc vim-scripts
The following NEW packages will be installed:
alsa-topology-conf alsamixer alsound2 libasound2-data libcanberra0 libexpat1
libgpmm2 libltdl7 libmagic-mgc libmagic1 libmpdec2 libogg0 libpython3.8
libpython3.8-minimal libpython3.8-stdlib libreadline8 libsqlite3-0 libssl1.1 libtdb1
libvorbis0a libvorbisfile3 mime-support readline-common sound-theme-freedesktop vim
vim-common vim-runtime xxd xz-utils
0 upgraded, 30 newly installed, 0 to remove and 0 not upgraded.
Need to get 14.4 MB of archives.
```

```

~ — qemu-system-aarch64 sudo ...36ec46a5cf6d: / — docker + sudo ~ — -zsh
Last login: Sat Feb 3 13:19:57 on ttys001
(base) nikhilshankar@Incharas-iMac ~ % docker ps
CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES
36ec46a5cf6d ubuntu:20.04 "/bin/bash" 5 minutes ago Up 5 minutes jolly_varahamihira
(base) nikhilshankar@Incharas-iMac ~ % docker commit 36ec46a5cf6d basic-image
sha256:2cd7a3e90cff9e475cc683890fd3e0333e61a1843950b1c7dd06e1b1fdc05d67
(base) nikhilshankar@Incharas-iMac ~ % docker images
REPOSITORY TAG IMAGE ID CREATED SIZE
basic-image latest 2cd7a3e90cff 7 seconds ago 167MB
updated-base-image latest ceba80a88288 14 hours ago 119MB
updated-base-image mem3cpu2 82a39ab097d3 14 hours ago 119MB
updated-base-image mem2cpu3 fcf8f94903ff 14 hours ago 119MB
updated-base-image mem2cpu2 d0f5353131a 14 hours ago 119MB
base-image mem3cpu3 7703ac014605 16 hours ago 119MB
base-image mem3cpu2 5751b22f0ffe 16 hours ago 119MB
base-image mem2cpu3 c3aca48aa0d1 16 hours ago 119MB
base-image mem2cpu2 745d2ecddcd8 16 hours ago 119MB
base-image latest 3e734bae3aea 17 hours ago 119MB
ubuntu latest 9cbdd1f76112 9 days ago 69.2MB
ubuntu 20.04 f8b1498b9544 11 days ago 65.7MB
inchrndr/collaborative-playlists latest d02ca9f16191 2 months ago 520MB
frontend-image latest d02ca9f16191 2 months ago 520MB
backend-server-1-image latest 10ce80dc9fc4 2 months ago 167MB
inchrndr/collaborative-playlists <none> 10ce80dc9fc4 2 months ago 167MB
backend-server-2-image latest 44956ddcc4367 2 months ago 167MB
inchrndr/collaborative-playlists <none> 44956ddcc4367 2 months ago 167MB
hello-world latest ee301c921b8a 9 months ago 9.14kB
(base) nikhilshankar@Incharas-iMac ~ %

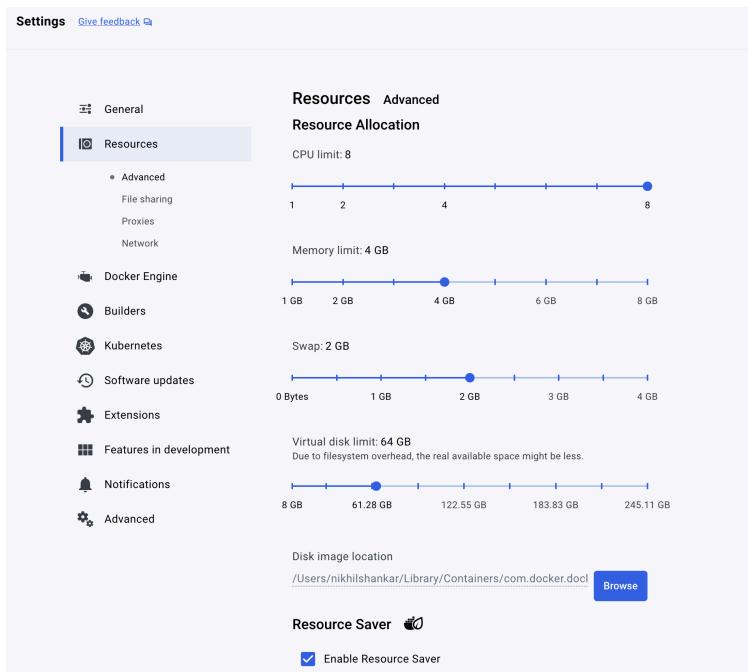
```

Currently, we have generated a Docker image through command-line instructions. Another approach involves creating a Docker image using a Dockerfile.

Explanation for all commands used

docker pull image-name:tag	Fetches a Docker image from a registry with the specified name and tag.
docker images	Displays a list of all available Docker images.
docker run image-name	Executes a Docker image, creating and launching a container based on that image.
docker run [container] image [command]	Initiates a container by running a specific command within the specified image.
docker ps	Shows a list of all currently running containers.
docker commit <container_id> <image_name>	Creates a new Docker image by capturing the file changes or settings of a running container.
docker history <image_name>	Provides a historical view of changes made to a Docker image.

Adjust Docker Preferences



Testing Scenarios

In the context of the virtual machine (VM), the experiment will be conducted under 4 distinct test conditions. These conditions will be replicated for Docker experiments to ensure uniformity in the obtained results.

RAM	CPU Cores
2	2
2	3
3	2
3	3

For Docker, we are using the sysbench library package: <https://github.com/akopytov/sysbench>

Reports and Results

In this section, we will test scenarios specifically related to sysbench CPU, Memory, and File I/O commands. Additionally, we will explore diverse configurations of the QEMU VM to analyze if varying VM configurations yield distinct results.

CPU Testing

In comparing CPU performance between QEMU and Docker, we will assess 2 test cases. Each test case will be executed for a duration of 30 seconds, using the sysbench command. The following test cases will be conducted:

```
``  
#!/bin/bash  
sysbench --test=cpu --cpu-max-prime=1000 --time=30 run  
  
#!/bin/bash  
sysbench --test=cpu --cpu-max-prime=2000 --time=30 run  
``
```

Memory Testing

In the context of memory testing, the following bash scripts utilizing sysbench will be employed. Each script focuses on specific memory block sizes and total memory sizes

```
``  
#!/bin/bash  
sysbench memory --memory-block-size=1G --memory-total-size=3G run  
  
#!/bin/bash  
sysbench memory --memory-block-size=512K --memory-total-size=512M run  
``
```

FILEIO Testing

For File I/O testing, two sysbench-supported modes will be employed:

1. Sequential Rewrite (seqrewr)
2. Combined random read/write (rndrw)

The file size will be maintained at a constant 2GB, and each test case will run for a duration of 30 seconds. The sysbench commands used for testing purposes are as follows:

```
``  
#!/bin/bash  
sysbench --num-threads=16 --test=fileio --file-total-size=3G --time=30 --file-test-mode=seqrewr  
prepare
```

```

sysbench --num-threads=16 --test=fileio --file-total-size=3G --time=30 --file-test-mode=seqrewr
run
sysbench --num-threads=16 --test=fileio --file-total-size=3G --time=30 --file-test-mode=seqrewr
cleanup
```
```
#!/bin/bash
sysbench --num-threads=16 --test=fileio --file-total-size=3G --time=30 --file-test-mode=rndrw
prepare
sysbench --num-threads=16 --test=fileio --file-total-size=3G --time=30 --file-test-mode=rndrw
run
sysbench --num-threads=16 --test=fileio --file-total-size=3G --time=30 --file-test-mode=rndrw
cleanup
```

```

## Results

Different configurations are evaluated in the following order -

- Configuration 1: 2GB RAM with 2 CPU Cores (**qcow2, raw, docker**)
- Configuration 2: 2GB RAM with 3 CPU Cores (**qcow2, raw, docker**)
- Configuration 3: 3GB RAM with 2 CPU Cores (**qcow2, raw, docker**)
- Configuration 4: 3GB RAM with 3 CPU Cores (**qcow2, raw, docker**)

## Configuration 1: 2GB RAM with 2 CPU Cores

To automate running CPU, Memory and FileIO tests for 5 iterations a bash script was created.

```

Users > nikhilshankar > Desktop > Docker > $ tests.sh
1 #!/bin/bash
2
3 for script in "cpu1000.sh" "cpu2000.sh" "fileiorrw.sh" "fileioseq.sh" "mem1M.sh" "mem512K.sh"; do
4 for i in 1 2 3 4 5; do
5 echo "Running iteration $i of $script"
6 ./script >> /logs/log_${script%.*}_$i.txt
7 echo "Iteration $i of $script done"
8 done
9 done
10
11 echo "All done"
12

```

### CPU Testing: 2GB RAM with 2 CPU Cores (**qcow2**)

## 1. Results for 2 GB 2 cores for max-prime = 1000 and time = 30 seconds

### ***Iteration1***

```
Initializing worker threads...
Threads started!
CPU speed:
events per second: 407939.80

General statistics:
total time: 30.0001s
total number of events: 12238442

Latency (ms):
min: 0.00
avg: 0.00
max: 6.59
95th percentile: 0.00
sum: 29252.42

Threads fairness:
events (avg/stddev): 12238442.0000/0.00
execution time (avg/stddev): 29.2524/0.00
```

### ***Iteration2***

```
Initializing worker threads...
Threads started!
CPU speed:
events per second: 408182.14

General statistics:
total time: 30.0004s
total number of events: 12246218

Latency (ms):
min: 0.00
avg: 0.00
max: 1.01
95th percentile: 0.00
sum: 29252.96

Threads fairness:
events (avg/stddev): 12246218.0000/0.00
execution time (avg/stddev): 29.2530/0.00
```

```
inchrvndr@inchrvndr:~$ █
```

### ***Iteration3***

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 408422.17

General statistics:
 total time: 30.0001s
 total number of events: 12253160

Latency (ms):
 min: 0.00
 avg: 0.00
 max: 4.70
 95th percentile: 0.00
 sum: 29246.99

Threads fairness:
 events (avg/stddev): 12253160.0000/0.00
 execution time (avg/stddev): 29.2470/0.00

inchrvndr@inchrvndr:~$
```

#### *Iteration4*

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 405814.27

General statistics:
 total time: 30.0001s
 total number of events: 12174871

Latency (ms):
 min: 0.00
 avg: 0.00
 max: 1.65
 95th percentile: 0.00
 sum: 29245.69

Threads fairness:
 events (avg/stddev): 12174871.0000/0.00
 execution time (avg/stddev): 29.2457/0.00
```

### ***Iteration5***

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 405814.27

General statistics:
 total time: 30.0001s
 total number of events: 12174871

Latency (ms):
 min: 0.00
 avg: 0.00
 max: 1.65
 95th percentile: 0.00
 sum: 29245.69

Threads fairness:
 events (avg/stddev): 12174871.0000/0.00
 execution time (avg/stddev): 29.2457/0.00
```

## **CPU Testing: 2GB RAM with 2 CPU Cores (qcow2)**

### **2. Results for 2 GB 2 cores for max-prime = 2000 and time = 30 seconds**

### ***Iteration1***

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 159112.63

General statistics:
 total time: 30.0007s
 total number of events: 4773810

Latency (ms):
 min: 0.01
 avg: 0.01
 max: 10.52
 95th percentile: 0.01
 sum: 29698.33

Threads fairness:
 events (avg/stddev): 4773810.0000/0.00
 execution time (avg/stddev): 29.6983/0.00
```

## ***Iteration2***

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 157247.73

General statistics:
 total time: 30.0002s
 total number of events: 4717643

Latency (ms):
 min: 0.01
 avg: 0.01
 max: 0.65
 95th percentile: 0.01
 sum: 29702.61

Threads fairness:
 events (avg/stddev): 4717643.0000/0.00
 execution time (avg/stddev): 29.7026/0.00
```

## ***Iteration3***

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 156856.49

General statistics:
 total time: 30.0002s
 total number of events: 4705904

Latency (ms):
 min: 0.01
 avg: 0.01
 max: 0.41
 95th percentile: 0.01
 sum: 29705.80

Threads fairness:
 events (avg/stddev): 4705904.0000/0.00
 execution time (avg/stddev): 29.7058/0.00
```

## ***Iteration4***

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 155423.05

General statistics:
 total time: 30.0008s
 total number of events: 4663105

Latency (ms):
 min: 0.01
 avg: 0.01
 max: 12.50
 95th percentile: 0.01
 sum: 29695.64

Threads fairness:
 events (avg/stddev): 4663105.0000/0.00
 execution time (avg/stddev): 29.6956/0.00
```

### *Iteration5*

```
Initializing worker threads...

Threads started!

CPU speed:
 events per second: 156707.87

General statistics:
 total time: 30.0001s
 total number of events: 4701432

Latency (ms):
 min: 0.01
 avg: 0.01
 max: 13.99
 95th percentile: 0.01
 sum: 29698.28

Threads fairness:
 events (avg/stddev): 4701432.0000/0.00
 execution time (avg/stddev): 29.6983/0.00
```

For the sake of keeping this report readable, concise, and clean, in place of screenshots, log files have been linked below for the respective iterations

### CPU Testing: 2GB RAM with 2 CPU Cores (**raw**)

1. Results for 2 GB 2 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### CPU Testing: 2GB RAM with 2 CPU Cores (**Docker**)

1. Results for 2 GB 2 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### Memory Testing: 2GB RAM with 2 CPU Cores (**qcow2**)

1. Results for 2 GB 2 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### Memory Testing: 2GB RAM with 2 CPU Cores (**raw**)

1. Results for 2 GB 2 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Memory Testing: 2GB RAM with 2 CPU Cores (docker)

1. Results for 2 GB 2 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 2GB RAM with 2 CPU Cores (qcow2)

1. Results for 2 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 2GB RAM with 2 CPU Cores (raw)

1. Results for 2 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

## FileIO Testing: 2GB RAM with 2 CPU Cores (docker)

- Results for 2 GB 2 cores for --file-total-size=3G --time=30  
--file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

- Results for 2 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

## Report & Analysis: 2GB RAM with 2 CPU Cores

All details like Number of events/second, Total time, Total number of events were recorded and tabulated.

Also, some useful observations like average, minimum and maximum number of events/second have been made note of and added on the last column.

*For better visibility of results, visit the [spreadsheet](#).*

### qcow2

| # | Image Type | RAM (-m) | CPU (-mp) | Syndb test mode | Parameter           | Value             | 1                       |            | 2                      |                         | 3          |                        | 4                       |            | 5                      |                       | Report                |                       |           |          |          |            |           |           |
|---|------------|----------|-----------|-----------------|---------------------|-------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-----------------------|-----------------------|-----------------------|-----------|----------|----------|------------|-----------|-----------|
|   |            |          |           |                 |                     |                   | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Average Events/Second | Minimum Events/Second | Maximum Events/Second |           |          |          |            |           |           |
| 5 | qcow2      | 2        | 2         | CPU             | --cpu-max-prime     | 2000              | 158112.63               | 30.0007s   | 4773810                | 157247.73               | 30.0020s   | 4171943                | 156856.49               | 30.0020s   | 4705904                | 156423.05             | 30.0007s              | 4663105               | 156707.47 | 30.0007s | 4701432  | 157069.554 | 155423.05 | 109112.63 |
|   |            |          |           |                 | --memory-block-size | 1M                | 32155.02                | 0.0311s    | 1024                   | 31600.54                | 0.0314s    | 1024                   | 29750.57                | 0.0335s    | 1024                   | 25419.91              | 0.0397s               | 1024                  | 25278.9   | 0.0398s  | 1024     | 28840.988  | 25278.9   | 32155.02  |
|   |            |          |           | Memory          | --memory-block-size | 512K              | 76245.7                 | 0.0128s    | 1024                   | 39585.28                | 0.0251s    | 1024                   | 70509.8                 | 0.0141s    | 1024                   | 41429.1               | 0.0294s               | 1024                  | 46221.25  | 0.0215s  | 1024     | 54797.585  | 39585.28  | 76245.7   |
|   |            |          |           |                 | FileIO              | --file-test-mode  | Sequential Rewrite      | 43989.41   | 30.0587s               | 1320232                 | 48763.39   | 30.3531s               | 1478106                 | 49727.17   | 30.0116s               | 1400381               | 66678.6               | 30.0090s              | 1998842   | 74399.25 | 30.0184s | 2231323    | 96711.584 | 43989.41  |
|   |            |          |           | FileIO          | --file-test-mode    | Random Read-Write | 72958.73                | 30.0135s   | 2187735                | 59996.47                | 30.0178s   | 1678833                | 66755.12                | 30.0115s   | 2001405                | 50287.84              | 30.0161s              | 1807418               | 69206.56  | 30.0146s | 2075162  | 63040.744  | 50287.84  | 72958.73  |

### raw

| 1 | raw | 2 | 2 | CPU                     |                     | --cpu-max-prime        | 1900                    | 41499.52   | 30.0001s               | 12489502                | 40214.48   | 30.0009s               | 1207921               | 40992.41              | 30.0007s              | 1220977   | 394347.41 | 30.0009s | 11811430  | 39712.55 | 30.0010s | 11911999   | 402920.274 | 394347.41 | 41499.52 |
|---|-----|---|---|-------------------------|---------------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-----------------------|-----------------------|-----------------------|-----------|-----------|----------|-----------|----------|----------|------------|------------|-----------|----------|
|   |     |   |   | Number of Events/second | Total Time          | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Average Events/Second | Minimum Events/Second | Maximum Events/Second |           |           |          |           |          |          |            |            |           |          |
| 1 | raw | 2 | 2 | CPU                     | --cpu-max-prime     | 2000                   | 161480.48               | 30.009s    | 4845198                | 159514.28               | 30.009s    | 4785966                | 154507.25             | 30.006s               | 4653577               | 107225.69 | 30.0007s  | 4732956  | 158397.35 | 30.009s  | 4752420  | 158325.006 | 154507.25  | 161480.48 |          |
|   |     |   |   |                         | --memory-block-size | 1M                     | 31078.8                 | 0.0329s    | 1024                   | 28435.04                | 0.0372s    | 1024                   | 25006.87              | 0.0390s               | 1024                  | 24652.12  | 0.0409s   | 1024     | 27641.782 | 0.0324s  | 1024     | 30256.08   | 27641.782  | 31078.8   |          |
| 1 | raw | 2 | 2 | Memory                  | --memory-block-size | 512K                   | 83074.83                | 0.0114s    | 1024                   | 43205.89                | 0.0228s    | 1024                   | 44291.57              | 0.0224s               | 1024                  | 45598.73  | 0.0218s   | 1024     | 55193.52  | 0.0150s  | 1024     | 54269.908  | 43200.89   | 83074.83  |          |
|   |     |   |   |                         | FileIO              | --file-test-mode       | Sequential Rewrite      | 36577.27   | 30.6469s               | 1264734                 | 42548.97   | 30.0208s               | 127519                | 48690.4               | 30.6389s              | 1479706   | 58071.31  | 30.3186s | 1866079   | 65812.36 | 30.0126s | 1964171    | 50133.862  | 36577.27  | 65812.36 |
| 1 | raw | 2 | 2 | FileIO                  | --file-test-mode    | Random Read-Write      | 61793.93                | 30.0164s   | 1852817                | 54095.47                | 30.0178s   | 1646994                | 59648.98              | 30.0153s              | 1770239               | 89376.8   | 30.0178s  | 1780332  | 53683.89  | 30.0139s | 1609258  | 57761.774  | 53683.89   | 61793.93  |          |
|   |     |   |   |                         | FileIO              | --file-test-mode       | Random Read-Write       | 61793.93   | 30.0164s               | 1852817                 | 54095.47   | 30.0178s               | 1646994               | 59648.98              | 30.0153s              | 1770239   | 89376.8   | 30.0178s | 1780332   | 53683.89 | 30.0139s | 1609258    | 57761.774  | 53683.89  | 61793.93 |

### docker

| RAM (-m) | CPU (-mp) | Syndb test mode | Parameter           | Value              | 1                       |            | 2                      |                         | 3          |                        | 4                       |            | 5                      |                       | Report                |                       |           |          |         |            |           |            |          |
|----------|-----------|-----------------|---------------------|--------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-----------------------|-----------------------|-----------------------|-----------|----------|---------|------------|-----------|------------|----------|
|          |           |                 |                     |                    | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Average Events/Second | Minimum Events/Second | Maximum Events/Second |           |          |         |            |           |            |          |
| 2        | 2         | CPU             | --cpu-max-prime     | 1000               | 367542.37               | 30.0003s   | 11026995               | 365208.35               | 30.0004s   | 10956713               | 368177.52               | 30.0003s   | 10985558               | 372416.36             | 30.0004s              | 11173148              | 331569.12 | 30.0004s | 9947493 | 360582.744 | 331569.12 | 11173148   |          |
|          |           |                 | --cpu-max-prime     | 2000               | 135129.74               | 30.0003s   | 4054983                | 144956.94               | 30.0006s   | 4338306                | 153871.62               | 30.0005s   | 4816479                | 155147.19             | 30.0006s              | 4645472               | 153963.84 | 30.0007s | 4619358 | 148541.866 | 4619358   | 148541.866 |          |
|          |           | Memory          | --memory-block-size | 1M                 | 5.14                    | 0.5802s    | 3                      | 32.47                   | 0.0904s    | 3                      | 28.04                   | 0.1058s    | 3                      | 30.48                 | 0.0876s               | 3                     | 28.7      | 0.1033s  | 3       | 24.966     | 0.1023s   | 3          | 30.48    |
|          |           |                 | --memory-block-size | 512K               | 79445.28                | 0.0123s    | 1024                   | 80310.58                | 0.0122s    | 1024                   | 69094.46                | 0.0140s    | 1024                   | 74694.09              | 0.0127s               | 1024                  | 79551.07  | 0.0123s  | 1024    | 76699.096  | 69094.46  | 1024       | 79551.07 |
|          |           | FileIO          | --file-test-mode    | Sequential Rewrite | 54110.49                | 30.0129s   | 1621986                | 41471.79                | 30.0168s   | 1242014                | 41812.38                | 30.0163s   | 1254985                | 407167.62             | 30.0224s              | 1221009               | 39755.55  | 30.0166s | 1191380 | 43581.566  | 39755.55  | 1621986    |          |
| 2        | 2         | FileIO          | --file-test-mode    | Random Read-Write  | 67484.67                | 30.0196s   | 2023433                | 47446.18                | 30.0164s   | 1422141                | 40542.16                | 30.0154s   | 1214680                | 45147.27              | 30.0256s              | 1353542               | 46485.18  | 30.0127s | 1383121 | 49421.092  | 40542.16  | 2023433    |          |

## Comparison of QEMU vs Docker: 2GB RAM with 2 CPU Cores

qcow2 vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter           | Value              | QEMU                  | Docker                |
|---|------------|----------|------------|--------------------|---------------------|--------------------|-----------------------|-----------------------|
|   |            |          |            |                    |                     |                    | Report                | Report                |
|   |            |          |            |                    |                     |                    | Average Events/second | Average Events/second |
| 5 | qcow2      | 2        | 2          | CPU                | --cpu-max-prime     | 1000               | 407313.042            | 360582.744            |
|   |            |          |            |                    | --cpu-max-prime     | 2000               | 157069.554            | 148541.866            |
|   |            |          |            | Memory             | --memory-block-size | 1G                 | 28840.988             | 24.966                |
|   |            |          |            |                    | --memory-block-size | 512K               | 54797.586             | 76699.096             |
|   |            |          |            | FileIO             | --file-test-mode    | Sequential Rewrite | 56711.564             | 43581.566             |
|   |            |          |            |                    | --file-test-mode    | Random Read-Write  | 63040.744             | 49421.092             |

raw vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter           | Value              | QEMU                  | Docker                |
|---|------------|----------|------------|--------------------|---------------------|--------------------|-----------------------|-----------------------|
|   |            |          |            |                    |                     |                    | Report                | Report                |
|   |            |          |            |                    |                     |                    | Average Events/second | Average Events/second |
| 1 | raw        | 2        | 2          | CPU                | --cpu-max-prime     | 1000               | 402626.274            | 360582.744            |
|   |            |          |            |                    | --cpu-max-prime     | 2000               | 158325.006            | 148541.866            |
|   |            |          |            | Memory             | --memory-block-size | 1G                 | 27641.782             | 24.966                |
|   |            |          |            |                    | --memory-block-size | 512K               | 54269.908             | 76699.096             |
|   |            |          |            | FileIO             | --file-test-mode    | Sequential Rewrite | 50133.862             | 43581.566             |
|   |            |          |            |                    | --file-test-mode    | Random Read-Write  | 57761.774             | 49421.092             |

### CPU Testing Analysis: 2GB RAM with 2 CPU Cores

According to our experiment, we observe that QEMU VM is faster than Docker.

As we see, when we increase the cpu-max-prime argument value the number of events per second decreases for our current experimental configuration. QEMU is slightly faster than Docker desktop on this MacBook chip

### Memory Testing Analysis: 2GB RAM with 2 CPU Cores

Based on the analysis conducted using the parameters --memory-block-size and -memory-total-size in the first test case, the findings reveal that the QEMU VM outperforms Docker. Conversely, in the results of the second test case, it is observed that Docker exhibits better performance compared to the QEMU VM.

### FileIO Testing Analysis: 2GB RAM with 2 CPU Cores

As per the results of both test cases, for sequential rewrite operations and combined random read/write QEMU is faster than the docker desktop

## Configuration 2: 2GB RAM with 3 CPU Cores

### CPU Testing: 2GB RAM with 3 CPU Cores (qcow2)

- Results for 2 GB 3 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 3 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

CPU Testing: 2GB RAM with 3 CPU Cores (**raw**)

1. Results for 2 GB 3 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 3 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

CPU Testing: 2GB RAM with 3 CPU Cores (**docker**)

1. Results for 2 GB 3 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 3 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

Memory Testing: 2GB RAM with 3 CPU Cores (**qcow2**)

1. Results for 2 GB 3 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 3 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

Memory Testing: 2GB RAM with 3 CPU Cores (**raw**)

1. Results for 2 GB 3 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 3 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Memory Testing: 2GB RAM with 3 CPU Cores (**docker**)

1. Results for 3 GB 3 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 2GB RAM with 3 CPU Cores (**qcow2**)

1. Results for 2 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 2 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 2GB RAM with 3 CPU Cores (**raw**)

1. Results for 2 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

### Iteration1, Iteration2, Iteration3, Iteration4, Iteration5

- Results for 2 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

### Iteration1, Iteration2, Iteration3, Iteration4, Iteration5

### FileIO Testing: 2GB RAM with 3 CPU Cores (docker)

- Results for 2 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

### Iteration1, Iteration2, Iteration3, Iteration4, Iteration5

- Results for 2 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

### Iteration1, Iteration2, Iteration3, Iteration4, Iteration5

### Report & Analysis: 2GB RAM with 3 CPU Cores

All details like Number of events/second, Total time, Total number of events were recorded and tabulated.

Also, some useful observations like average, minimum and maximum number of events/second have been made note of and added on the last column.

*For better visibility of results, visit the [spreadsheet](#).*

### qcow2

| Image Type | RAM (m) | CPU (core) | System test mode | Parameter           | Value              | Report                  |            |                        |                         |            |                        |                       |          |
|------------|---------|------------|------------------|---------------------|--------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-----------------------|----------|
|            |         |            |                  |                     |                    | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Average Events/second |          |
| qcow2      | 2       | 3          | CPU              | --cpu-mem-prime     | 1000               | 61715.28                | 30.000ms   | 1200043                | 7                       | 30.000ms   | 1199331                | 397536.39             |          |
|            |         |            |                  | --cpu-mem-prime     | 150500.64          | 4513444                 | 30.0007s   | 4513444                | 154961.57               | 30.0007s   | 154901.02              | 4546028               |          |
|            |         |            | Memory           | --memory-block-size | 1G                 | 6.01                    | 0.4974s    | 3                      | 7.01                    | 0.4270s    | 3                      | 16.56                 | 4647394  |
|            |         |            | Memory           | --memory-block-size | 512K               | 96250.47                | 0.0102s    | 1024                   | 88672.3                 | 0.0113s    | 1024                   | 100776.32             | 0.0097s  |
|            |         |            | FileIO           | --file-test-mode    | Sequential Rewrite | 26927.62                | 30.0168s   | 903241                 | 26933.77                | 30.0154s   | 787955                 | 27756.96              | 30.0351s |
|            |         |            | FileIO           | --file-test-mode    | Random Read-Write  | 52371.23                | 30.0478s   | 1569888                | 35779.68                | 30.0424s   | 1072985                | 27794.6               | 30.0586s |
|            |         |            |                  |                     |                    |                         |            |                        | 816414                  | 16998.11   | 30.0523s               | 470928                | 10461.62 |
|            |         |            |                  |                     |                    |                         |            |                        | 52291                   | 30943.104  | 30.0434s               | 46467.62              | 18451.02 |
|            |         |            |                  |                     |                    |                         |            |                        | 52291                   | 30943.104  | 30.0434s               | 46467.62              | 18451.02 |

### raw

| Image Type | RAM (m) | CPU (core) | System test mode | Parameter           | Value              | Report                  |            |                        |                         |            |                        |                       |          |
|------------|---------|------------|------------------|---------------------|--------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-----------------------|----------|
|            |         |            |                  |                     |                    | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Average Events/second |          |
| raw        | 2       | 3          | CPU              | --cpu-mem-prime     | 1000               | 395147.96               | 30.0005s   | 400000.38              | 90.0011s                | 12000310   | 395147.96              | 30.0005s              |          |
|            |         |            |                  | --cpu-mem-prime     | 2000               | 154020.44               | 30.0003s   | 145204.04              | 30.0004s                | 4469606    | 154020.44              | 30.0003s              |          |
|            |         |            | Memory           | --memory-block-size | 1G                 | 47332.18                | 0.0210s    | 3                      | 47871.44                | 0.0207s    | 3                      | 46496.13              | 0.0211s  |
|            |         |            | Memory           | --memory-block-size | 512K               | 94282.15                | 0.0103s    | 1024                   | 97144.94                | 0.0104s    | 1024                   | 94712.52              | 0.0104s  |
|            |         |            | FileIO           | --file-test-mode    | Sequential Rewrite | 23276.91                | 30.0389s   | 705202                 | 22705.28                | 30.0256s   | 679706                 | 38580.93              | 30.0197s |
|            |         |            | FileIO           | --file-test-mode    | Random Read-Write  | 21458.15                | 30.0257s   | 20708.66               | 30.0443s                | 682053     | 10855.10               | 30.0372s              | 329410   |
|            |         |            |                  |                     |                    |                         |            |                        | 70344.42                | 310165     | 90484.84               | 30.0497s              | 294993   |
|            |         |            |                  |                     |                    |                         |            |                        | 54625.89                | 34403.444  | 22705.28               | 44167.60              | 21458.15 |

### docker

| RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter | Value               | 1                  |                        |                      |            |                        | 2          |                        |                      |            |                        | 3                    |            |                        |                      |            | 4                      |                      |                    |                    |                    | Report |  |  |
|----------|------------|--------------------|-----------|---------------------|--------------------|------------------------|----------------------|------------|------------------------|------------|------------------------|----------------------|------------|------------------------|----------------------|------------|------------------------|----------------------|------------|------------------------|----------------------|--------------------|--------------------|--------------------|--------|--|--|
|          |            |                    |           |                     | Total Time         | Total Number of Events | Number of Events/sec | Total Time | Total Number of Events | Total Time | Total Number of Events | Number of Events/sec | Total Time | Total Number of Events | Number of Events/sec | Total Time | Total Number of Events | Number of Events/sec | Total Time | Total Number of Events | Number of Events/sec | Average Events/sec | Minimum Events/sec | Maximum Events/sec |        |  |  |
| 2        | 3          |                    | CPU       | --cpu-max-prime     | 1000               | 366996.67              | 30.0001s             | 11007147   | 33329.4                | 30.0002s   | 9991144                | 361012.64            | 30.0005s   | 1033982                | 344578.58            | 30.0005s   | 10337795               | 304484.17            | 30.0005s   | 8096127                | 343200.692           | 300498.17          | 11097147           |                    |        |  |  |
|          |            |                    | CPU       | --cpu-max-prime     | 2000               | 133447.6               | 30.0004s             | 4003562    | 142926.67              | 30.0005s   | 4288106                | 151801.68            | 30.0002s   | 4554238                | 150896.89            | 30.0002s   | 4527004                | 142381.31            | 30.0002s   | 4271642                | 144290.83            | 142381.31          | 4954238            |                    |        |  |  |
|          |            |                    | Memory    | --memory-block-size | 1G                 | 7.62                   | 0.3923s              | 3          | 4.88                   | 0.6141s    | 3                      | 6.43                 | 0.4659s    | 3                      | 11.04                | 0.2710s    | 3                      | 21.18                | 0.1410s    | 3                      | 10.23                | 6.43               | 3                  |                    |        |  |  |
|          |            |                    | Memory    | --memory-block-size | 512K               | 89719.96               | 0.0110s              | 1024       | 83497.56               | 0.0110s    | 1024                   | 87393.45             | 0.0113s    | 1024                   | 94922.12             | 0.0104s    | 1024                   | 89402.174            | 83457.56   | 1024                   |                      |                    |                    |                    |        |  |  |
|          |            |                    | FileIO    | --file-test-mode    | Sequential Rewrite | 42789.43               | 30.0140s             | 1262287    | 40290.8                | 30.0110s   | 1207943                | 18790.29             | 30.7398s   | 574282                 | 20786.27             | 30.1727s   | 625142                 | 28707.56             | 30.4730s   | 872959                 | 30265.792            | 18750.29           | 1262287            |                    |        |  |  |
|          |            |                    | FileIO    | --file-test-mode    | Random Read-Write  | 57189.03               | 30.0191s             | 1714615    | 42012.32               | 30.0020s   | 150946                 | 41997.66             | 30.0235s   | 1289973                | 50152.8              | 30.0212s   | 1509524                | 42111.38             | 30.0152s   | 1291958                | 46667.398            | 41987.86           | 1714615            |                    |        |  |  |

## Comparison of QEMU vs Docker: 2GB RAM with 3 CPU Cores

qcow2 vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter | Value               | QEMU                  |                       | Docker                |                       |  |
|---|------------|----------|------------|--------------------|-----------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|--|
|   |            |          |            |                    |           |                     | Report                |                       | Report                |                       |  |
|   |            |          |            |                    |           |                     | Average Events/second | Average Events/second | Average Events/second | Average Events/second |  |
| 6 | qcow2      | 2        | 3          |                    | CPU       | --cpu-max-prime     | 1000                  | 400641.466            | 343000.692            |                       |  |
|   |            |          |            |                    | CPU       | --cpu-max-prime     | 2000                  | 153453.206            | 144290.83             |                       |  |
|   |            |          |            |                    | Memory    | --memory-block-size | 1G                    | 14.016                | 10.23                 |                       |  |
|   |            |          |            |                    | Memory    | --memory-block-size | 512K                  | 95196.008             | 89402.174             |                       |  |
|   |            |          |            |                    | FileIO    | --file-test-mode    | Sequential Rewrite    | 25234.012             | 30265.792             |                       |  |
|   |            |          |            |                    | FileIO    | --file-test-mode    | Random Read-Write     | 30943.104             | 46567.398             |                       |  |

raw vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter | Value               | QEMU                  |                       | Docker                |                       |  |
|---|------------|----------|------------|--------------------|-----------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|--|
|   |            |          |            |                    |           |                     | Report                |                       | Report                |                       |  |
|   |            |          |            |                    |           |                     | Average Events/second | Average Events/second | Average Events/second | Average Events/second |  |
| 2 | raw        | 2        | 3          |                    | CPU       | --cpu-max-prime     | 1000                  | 395302.012            | 343000.692            |                       |  |
|   |            |          |            |                    | CPU       | --cpu-max-prime     | 2000                  | 144886.966            | 144290.83             |                       |  |
|   |            |          |            |                    | Memory    | --memory-block-size | 1G                    | 47202.098             | 10.23                 |                       |  |
|   |            |          |            |                    | Memory    | --memory-block-size | 512K                  | 94263.338             | 89402.174             |                       |  |
|   |            |          |            |                    | FileIO    | --file-test-mode    | Sequential Rewrite    | 34403.444             | 30265.792             |                       |  |
|   |            |          |            |                    | FileIO    | --file-test-mode    | Random Read-Write     | 14525.892             | 46567.398             |                       |  |

## CPU Testing Analysis: 2GB RAM with 3 CPU Cores

According to our experiment, we observe that QEMU VM is faster than Docker.

As we see, when we increase the cpu-max-prime argument value the number of events per second decreases for our current experimental configuration. QEMU is slightly faster than Docker desktop on this MacBook chip

## Memory Testing Analysis: 2GB RAM with 3 CPU Cores

Based on the analysis conducted using the parameters --memory-block-size and -memory-total-size in both the test cases, the findings reveal that the QEMU VM outperforms Docker.

## FileIO Testing Analysis: 2GB RAM with 3 CPU Cores

As per the results of both test cases, for sequential rewrite operations and combined random read/write docker desktop is faster than QEMU, except the first test case for raw image type.

## Configuration 3: 3GB RAM with 2 CPU Cores

### CPU Testing: 3GB RAM with 2 CPU Cores (**qcow2**)

1. Results for 3 GB 2 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### CPU Testing: 3GB RAM with 2 CPU Cores (**raw**)

1. Results for 3 GB 2 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### CPU Testing: 3GB RAM with 2 CPU Cores (**docker**)

1. Results for 3 GB 2 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### Memory Testing: 3GB RAM with 2 CPU Cores (**qcow2**)

1. Results for 3 GB 2 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Memory Testing: 3GB RAM with 2 CPU Cores (raw)

1. Results for 3 GB 2 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Memory Testing: 3GB RAM with 2 CPU Cores (docker)

1. Results for 3 GB 2 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 3GB RAM with 2 CPU Cores (qcow2)

1. Results for 3 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

## FileIO Testing: 3GB RAM with 2 CPU Cores (raw)

1. Results for 3 GB 2 cores for --file-total-size=3G --time=30  
--file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

## **Iteration1, Iteration2, Iteration3, Iteration4, Iteration5**

## FileIO Testing: 3GB RAM with 2 CPU Cores (docker)

1. Results for 3 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=seqrwr and time = 30 seconds

## **Iteration1, Iteration2, Iteration3, Iteration4, Iteration5**

2. Results for 3 GB 2 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

## **Iteration1, Iteration2, Iteration3, Iteration4, Iteration5**

## Report & Analysis: 3GB RAM with 2 CPU Cores

All details like Number of events/second, Total time, Total number of events were recorded and tabulated.

Also, some useful observations like average, minimum and maximum number of events/second have been made note of and added on the last column.

*For better visibility of results, visit the spreadsheet.*

qcow2

| B          | C        | D         | E            | F                  | G                 | H               | I          | J                      | K               | L          | M               | N          | O               | P          | Q               | R          | S               | T          | U               | V                       | W                       | X                       | Y         | Z       |
|------------|----------|-----------|--------------|--------------------|-------------------|-----------------|------------|------------------------|-----------------|------------|-----------------|------------|-----------------|------------|-----------------|------------|-----------------|------------|-----------------|-------------------------|-------------------------|-------------------------|-----------|---------|
| Image Type | RAM (cm) | CPU (amp) | System/ Test | Parameter          | Value             | Number of Event | Total Time | Total Number of Events | Number of Event | Total Time | Number of Event | Average Number of Event | Minimum Number of Event | Maximum Number of Event | Report    |         |
| gpcw2      | 3        | 2         | GPU          | -cpu-max-prime     | 1000              | 300000          | 100000000  | 100000000              | 100000000       | 300000     | 100000000       | 300000     | 100000000       | 300000     | 100000000       | 300000     | 100000000       | 300000     | 100000000       | 300000000               | 100000000               | 300000000               | 300000000 |         |
|            |          |           | GPU          | -cpu-max-prime     | 2000              | 1534247         | 300000     | 4600427                | 15255241        | 300000     | 4507006         | 1448743    | 300000          | 4486471    | 1448743         | 300000     | 4484958         | 1448743    | 300000          | 4484958                 | 1448743                 | 300000                  | 4484958   | 1448743 |
|            |          |           | Memory       | -memory-block-size | 32K               | 26.91           | 0.1108e    | 3                      | 30.46           | 0.0981e    | 3               | 33.06      | 0.0952e         | 3          | 33.06           | 0.0952e    | 3               | 32.51      | 0.0918e         | 3                       | 31.28e                  | 0.0918e                 | 33.46e    | 0.0918e |
|            |          |           | Memory       | -memory-block-size | 64K               | 58.01           | 0.0103e    | 1024                   | 58270.7         | 0.0103e    | 1024            | 59963.3    | 0.0099e         | 1024       | 59817.0         | 0.0103e    | 1024            | 59817.0    | 0.0103e         | 1024                    | 59817.0                 | 0.0103e                 | 59963.3   | 0.0103e |
|            |          |           | FileIO       | -file-test-mode    | Sequential        | 250.57          | 0.0001e    | 1024                   | 250.57          | 0.0001e    | 1024            | 75007      | 0.0001e         | 1024       | 75007           | 0.0001e    | 1024            | 74886      | 0.0001e         | 1024                    | 74886                   | 0.0001e                 | 75007     | 0.0001e |
|            |          |           | FileIO       | -file-test-mode    | Random Read-Write | 35042.6         | 0.0214e    | 1050121                | 24546.32        | 0.0214e    | 1050121         | 79454.2    | 24478.5         | 0.0303e    | 745218          | 2522.70    | 0.0303e         | 75268      | 25062.5         | 0.0303e                 | 502494                  | 753646                  | 25062.5   | 45632.5 |

raw

| Image Type | RAM (m) | CPU (smpl) | Sybtest test mode | Parameter          | Value               | 1                |            |                  |            |                  |            | 2                |            |                  |            |                  |            | 3                |            |                  |                    |                    |                    | 4                   |          |          |           |          |          | Report    |          |         |           |          |  |
|------------|---------|------------|-------------------|--------------------|---------------------|------------------|------------|------------------|------------|------------------|------------|------------------|------------|------------------|------------|------------------|------------|------------------|------------|------------------|--------------------|--------------------|--------------------|---------------------|----------|----------|-----------|----------|----------|-----------|----------|---------|-----------|----------|--|
|            |         |            |                   |                    |                     | Number of Events | Total Time | Number of Events | Average Events/sec | Minimum Events/sec | Maximum Events/sec | Average Seconds/sec |          |          |           |          |          |           |          |         |           |          |  |
| raw        | 3       | 2          | CPU               | -cpu_max_prime     | 1000                | 397555.07        | 30.0000s   | 1192796          | 398404.45  | 30.0000s         | 11942074   | 395653.09        | 30.0000s   | 1169262          | 306862.24  | 30.0010s         | 11016444   | 382744.54        | 30.0000s   | 11483692         | 380743.474         | 30.0000s           | 11483692           | 366242.24           | 30.0000s | 30.0000s | 30.0000s  | 30.0000s | 30.0000s | 30.0000s  |          |         |           |          |  |
|            |         |            | CPU               | -cpu_max_prime     | 2000                | 152900.00        | 30.0000s   | 407443           | 398404.45  | 30.0000s         | 4466202    | 395653.09        | 30.0000s   | 4517948          | 398404.45  | 30.0000s         | 4499184    | 395653.09        | 30.0000s   | 4430915          | 398404.45          | 30.0000s           | 4329913            | 395653.09           | 30.0000s | 4329913  | 395653.09 | 30.0000s | 4329913  | 395653.09 | 30.0000s | 4329913 | 395653.09 | 30.0000s |  |
|            |         |            | Memory            | -memory_block-size | 1G                  | 30.0000s         | 0.0000s    | 3                | 44660.07   | 30.0000s         | 4          | 43466.37         | 30.0000s   | 5                | 42362.67   | 30.0000s         | 6          | 41260.97         | 30.0000s   | 7                | 40159.27           | 30.0000s           | 8                  | 39057.57            | 30.0000s | 9        | 37955.87  | 30.0000s | 10       | 36854.17  | 30.0000s | 11      | 35752.47  | 30.0000s |  |
|            |         |            | Memory            | -memory_block-size | 512K                | 91539.49         | 0.0108s    | 1024             | 90340.37   | 0.0105s          | 1024       | 89238.65         | 0.0111s    | 1024             | 88136.93   | 0.0109s          | 1024       | 87035.21         | 0.0109s    | 1024             | 85933.71           | 0.0113s            | 1024               | 84831.98            | 0.0115s  | 1024     | 83730.25  | 0.0113s  | 1024     | 82628.54  | 0.0115s  | 1024    | 81526.81  | 0.0115s  |  |
|            |         |            | FileIO            | -file-test-mode    | Sequential Requests | 27688.76         | 0.0226s    | 634095           | 24893.09   | 0.0216s          | 706437     | 25097.43         | 0.0226s    | 706437           | 25304.73   | 0.0226s          | 706437     | 25510.03         | 0.0226s    | 706437           | 25715.33           | 0.0240s            | 706437             | 25921.63            | 0.0240s  | 706437   | 26127.93  | 0.0240s  | 706437   | 26334.23  | 0.0240s  | 706437  | 26540.53  | 0.0240s  |  |
|            |         |            | FileIO            | -file-test-mode    | Random Read/Write   | 34691.34         | 0.0240s    | 103997           | 26045.74   | 0.0240s          | 28541      | 26297.42         | 0.0273s    | 706437           | 26597.42   | 0.0273s          | 706437     | 26897.42         | 0.0304s    | 706437           | 27197.42           | 0.0304s            | 706437             | 27497.42            | 0.0304s  | 706437   | 27797.42  | 0.0304s  | 706437   | 28097.42  | 0.0304s  | 706437  | 28397.42  | 0.0304s  |  |

docker

| A       | B         | C                | D                  | E                  | F                | G          | H                      | I                | J          | K                      | L                | M          | N                      | O                | P          | Q                      | R                | S          | T                      | U                         | V                 | W         |
|---------|-----------|------------------|--------------------|--------------------|------------------|------------|------------------------|------------------|------------|------------------------|------------------|------------|------------------------|------------------|------------|------------------------|------------------|------------|------------------------|---------------------------|-------------------|-----------|
| RAM (m) | CPU (amp) | Sybase test mode | Parameter          | Value              | Number of Events | Total Time | Total Number of Events | Number of Events | Total Time | Total Number of Events | Number of Events | Total Time | Total Number of Events | Number of Events | Total Time | Total Number of Events | Number of Events | Total Time | Total Number of Events | Average Minimum EventTime | Minimum EventTime | Report    |
| 3       | 2         | CPU              | -cpu-max-prime     | 1000               | 387921.04        | 30.0000s   | 11638139               | 36957979         | 30.0000s   | 11100136               | 43502580         | 30.0000s   | 10365996               | 321031.31        | 30.0000s   | 9631856                | 294219.43        | 30.0000s   | 8829943                | 346735.86                 | 294219.43         | 11638139  |
|         |           | CPU              | -cpu-prime-max     | 2000               | 105460.47        | 30.0000s   | 30641639               | 1020244.34       | 30.0000s   | 3001468                | 110035.63        | 30.0010s   | 323169                 | 12865.25         | 30.0000s   | 3693584                | 346526           | 127134.73  | 30.0000s               | 11351774                  | 110035.63         | 30.004562 |
|         | Memory    | Memory           | -memory-block-size | 1G                 | 7.2              | 0.3991s    | 17                     | 17.06            | 0.1748s    | 14                     | 14.47            | 0.2020s    | 14                     | 14.47            | 0.2020s    | 14                     | 2.2344           | 0.1748s    | 14                     | 10.384                    | 2.49              | 3         |
|         |           | Memory           | -memory-block-size | 2G                 | 10.4             | 0.3991s    | 10                     | 10.40            | 0.1748s    | 10                     | 10.40            | 0.2020s    | 10                     | 10.40            | 0.2020s    | 10                     | 1.024            | 0.1748s    | 10                     | 10.384                    | 2.49              | 3         |
|         | FileIO    | FileIO           | -file-test-mode    | Sequential Rewrite | 18853.63         | 30.0300s   | 56912                  | 34902.04         | 30.0300s   | 1040951                | 2117.37          | 30.0400s   | 634174                 | 25261.27         | 30.0500s   | 757904                 | 28135.44         | 30.1400s   | 708852                 | 247157.13                 | 2117.37           | 1040861   |
|         |           | FileIO           | -file-test-mode    | Random Read-Write  | 104.9            | 0.3504s    | 313065                 | 12571.00         | 0.3504s    | 375620                 | 17106.93         | 0.3500s    | 516141                 | 21294.35         | 0.3042s    | 637702                 | 17359.05         | 0.3000s    | 752521                 | 17359.05                  | 0.3000s           | 752521    |

## Comparison of QEMU vs Docker: 3GB RAM with 2 CPU Cores

## qcow2 vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter           | Value              | QEMU                  | Docker                |
|---|------------|----------|------------|--------------------|---------------------|--------------------|-----------------------|-----------------------|
|   |            |          |            |                    |                     |                    | Report                | Report                |
|   |            |          |            |                    |                     |                    | Average Events/second | Average Events/second |
| 7 | qcow2      | 3        | 2          | CPU                | --cpu-max-prime     | 1000               | 387845.198            | 343735.856            |
|   |            |          |            | CPU                | --cpu-max-prime     | 2000               | 149446.948            | 113517.748            |
|   |            |          |            | Memory             | --memory-block-size | 1G                 | 31.284                | 10.384                |
|   |            |          |            | Memory             | --memory-block-size | 512K               | 97855.668             | 84749.458             |
|   |            |          |            | FileIO             | --file-test-mode    | Sequential Rewrite | 24829.704             | 24757.15              |
|   |            |          |            | FileIO             | --file-test-mode    | Random Read-Write  | 26855.502             | 17329.57              |

## raw vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter           | Value              | QEMU                  | Docker                |
|---|------------|----------|------------|--------------------|---------------------|--------------------|-----------------------|-----------------------|
|   |            |          |            |                    |                     |                    | Report                | Report                |
|   |            |          |            |                    |                     |                    | Average Events/second | Average Events/second |
| 3 | raw        | 3        | 2          | CPU                | --cpu-max-prime     | 1000               | 387043.474            | 343735.856            |
|   |            |          |            | CPU                | --cpu-max-prime     | 2000               | 149150.912            | 113517.748            |
|   |            |          |            | Memory             | --memory-block-size | 1G                 | 42483.866             | 10.384                |
|   |            |          |            | Memory             | --memory-block-size | 512K               | 85622.948             | 84749.458             |
|   |            |          |            | FileIO             | --file-test-mode    | Sequential Rewrite | 25261.52              | 24757.15              |
|   |            |          |            | FileIO             | --file-test-mode    | Random Read-Write  | 27675.676             | 17329.57              |

## CPU Testing Analysis: 3GB RAM with 2 CPU Cores

According to our experiment, we observe that QEMU VM is faster than Docker.

As we see, when we increase the `cpu-max-prime` argument value the number of events per second decreases for our current experimental configuration. QEMU is slightly faster than Docker desktop on this MacBook chip.

## Memory Testing Analysis: 3GB RAM with 2 CPU Cores

Based on the analysis conducted using the parameters --memory-block-size and

-memory-total-size in both the test cases, the findings reveal that the QEMU VM outperforms Docker.

## FileIO Testing Analysis: 3GB RAM with 2 CPU Cores

As per the results of both test cases, for sequential rewrite operations and combined random read/write QEMU is faster than Docker Desktop, but comes very close in case of sequential rewrite operations.

---

## Configuration 4: 3GB RAM with 3 CPU Cores

### CPU Testing: 3GB RAM with 3 CPU Cores (**qcow2**)

1. Results for 3 GB 3 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### CPU Testing: 3GB RAM with 3 CPU Cores (**raw**)

1. Results for 3 GB 3 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### CPU Testing: 3GB RAM with 3 CPU Cores (**docker**)

1. Results for 3 GB 3 cores for max-prime = 1000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for max-prime = 2000 and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

### Memory Testing: 3GB RAM with 3 CPU Cores (**qcow2**)

1. Results for 3 GB 3 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Memory Testing: 3GB RAM with 3 CPU Cores (raw)

1. Results for 3 GB 3 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Memory Testing: 3GB RAM with 3 CPU Cores (docker)

1. Results for 3 GB 3 cores for --memory-block-size=1G --memory-total-size=3G and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --memory-block-size=512K --memory-total-size=512M and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 3GB RAM with 3 CPU Cores (qcow2)

1. Results for 3 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 3GB RAM with 3 CPU Cores (raw)

1. Results for 3 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### FileIO Testing: 3GB RAM with 3 CPU Cores (docker)

1. Results for 3 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=seqrewr and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

2. Results for 3 GB 3 cores for --file-total-size=3G --time=30 --file-test-mode=rndrw and time = 30 seconds

[Iteration1](#), [Iteration2](#), [Iteration3](#), [Iteration4](#), [Iteration5](#)

#### Report & Analysis: 3GB RAM with 3 CPU Cores

All details like Number of events/second, Total time, Total number of events were recorded and tabulated.

Also, some useful observations like average, minimum and maximum number of events/second have been made note of and added on the last column.

*For better visibility of results, visit the [spreadsheet](#).*

qcow2

| Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter                  | Value              | 1                       |            | 2                      |                         | 3          |                        | 4                       |            | 5                      |                         | Report     |                        |                         |          |
|------------|----------|------------|--------------------|----------------------------|--------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|----------|
|            |          |            |                    |                            |                    | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second |          |
| qcow2      | 3        | 3          | CPU                | --cpu-max-prime            | 1000               | 359047.5                | 30.0002s   | 11851748               | 392391.16               | 30.0007s   | 11772518               | 391464.24               | 30.0008s   | 11744506               | 391229.55               | 30.0011s   | 11737714               | 388960.49               | 30.0009s |
|            |          |            |                    | --cpu-max-prime            | 2000               | 152811.91               | 30.0003s   | 45847474               | 151859.7                | 30.0004s   | 4056984                | 1494646.16              | 30.0007s   | 4489861                | 151802.28               | 30.0006s   | 4557217                | 144224.59               | 30.0004s |
|            |          |            |                    | Memory --memory-block-size | 1G                 | 1.5                     | 0.0105s    | 1024                   | 3.5                     | 0.0105s    | 3                      | 3                       | 0.0105s    | 4489861                | 151802.28               | 30.0007s   | 4557217                | 144224.59               | 30.0004s |
|            |          |            |                    | Memory --memory-block-size | 512K               | 91914.61                | 0.0105s    | 1024                   | 93824.22                | 0.0105s    | 1024                   | 91874.43                | 0.0121s    | 1024                   | 89854.19                | 0.0121s    | 1024                   | 93827.07                | 0.0105s  |
|            |          |            |                    | FileIO --file-test-mode    | Sequential Rewrite | 22987.43                | 30.0167s   | 698707                 | 25196.2                 | 30.0196s   | 754282                 | 23828.42                | 30.0206s   | 713306                 | 22044.23                | 30.0516s   | 678272                 | 27085.89                | 30.0469s |
|            |          |            |                    | FileIO --file-test-mode    | Random Read-Write  | 35729.5                 | 30.0207s   | 1070607                | 27648.61                | 30.0234s   | 826071                 | 27335.65                | 30.0389s   | 819106                 | 29768.98                | 30.0259s   | 891816                 | 30060.13                | 30.0270s |

raw

| Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter                  | Value              | 1                       |            | 2                      |                         | 3          |                        | 4                       |            | 5                      |                         | Report     |                        |                         |          |
|------------|----------|------------|--------------------|----------------------------|--------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|------------|------------------------|-------------------------|----------|
|            |          |            |                    |                            |                    | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second | Total Time | Total Number of Events | Number of Events/second |          |
| raw        | 3        | 3          | CPU                | --cpu-max-prime            | 1000               | 384927.06               | 30.0002s   | 11448150               | 392027.63               | 30.0007s   | 1178051                | 391633.76               | 30.0006s   | 11744670               | 39134.15                | 30.0011s   | 11740129               | 388432.59               | 30.0010s |
|            |          |            |                    | --cpu-max-prime            | 2000               | 152414.24               | 30.0008s   | 4572790                | 151616.47               | 30.0020s   | 4549360                | 149382.24               | 30.0011s   | 4481888                | 152324.52               | 30.0008s   | 4571244                | 144014.14               | 30.0020s |
|            |          |            |                    | Memory --memory-block-size | 1G                 | 30537.88                | 0.0249s    | 3                      | 46726.95                | 0.0221s    | 3                      | 47306.66                | 0.0209s    | 3                      | 47413.63                | 0.0209s    | 3                      | 47397.27                | 0.0203s  |
|            |          |            |                    | Memory --memory-block-size | 512K               | 90033.84                | 0.0105s    | 1024                   | 88679.79                | 0.0111s    | 1024                   | 85629.94                | 0.0112s    | 1024                   | 95933.86                | 0.0102s    | 1024                   | 9825.71                 | 0.0100s  |
|            |          |            |                    | FileIO --file-test-mode    | Sequential Rewrite | 22937.23                | 30.0517s   | 699365                 | 254513.13               | 30.0524s   | 700718                 | 24610.46                | 30.0506s   | 72626                  | 21040.02                | 30.0424s   | 624310                 | 30.0442s                | 30.0546s |
|            |          |            |                    | FileIO --file-test-mode    | Random Read-Write  | 37980.15                | 30.0521s   | 1135555                | 2728.1                  | 30.0386s   | 690670                 | 30428.71                | 30.0259s   | 626569                 | 31482.31                | 30.0386s   | 942993                 | 31254.17                | 30.0266s |

docker

| A | B | C | D   | E                          | F                  | G        | H        | I       | J         | K        | L       | M        | N        | O       | P         | Q        | R       | S         |          |          | T         |          |           | U                     |                       |                       | V         |          |          |
|---|---|---|-----|----------------------------|--------------------|----------|----------|---------|-----------|----------|---------|----------|----------|---------|-----------|----------|---------|-----------|----------|----------|-----------|----------|-----------|-----------------------|-----------------------|-----------------------|-----------|----------|----------|
|   |   |   |     |                            |                    |          |          |         |           |          |         |          |          |         |           |          |         | 1         | 2        | 3        | 4         | 5        | Report    | Average Events/second | Minimum Events/second | Maximum Events/second |           |          |          |
| 3 | 3 | 3 | CPU | --cpu-max-prime            | 1000               | 30118.67 | 30.001s  | 697133  | 28675.31  | 30.0004s | 6004638 | 28613.14 | 30.0005s | 6202248 | 27910.70  | 30.0005s | 6004638 | 28613.14  | 30.0005s | 28613.14 | 28613.14  | 28613.14 | 28613.14  | 28613.14              | 28613.14              | 28613.14              | 28613.14  | 28613.14 | 28613.14 |
|   |   |   |     | --cpu-max-prime            | 2000               | 12520.26 | 30.0009s | 3320042 | 125152.05 | 30.0005s | 3454540 | 1474715  | 30.0009s | 4422940 | 140311.68 | 30.0009s | 4209478 | 144175.54 | 30.0009s | 434216   | 134264.02 | 30.0009s | 4422940   | 144224.59             | 30.0009s              | 4422940               | 144224.59 | 30.0009s |          |
|   |   |   |     | Memory --memory-block-size | 1G                 | 8.14     | 0.3677s  | 3       | 21.34     | 0.3398s  | 3       | 24.58    | 0.2166s  | 3       | 34.16     | 0.0873s  | 3       | 34.85     | 0.0859s  | 3        | 46.61     | 0.0846s  | 3         | 46.61                 | 0.0846s               | 3                     | 46.61     | 0.0846s  |          |
|   |   |   |     | Memory --memory-block-size | 512K               | 93586.84 | 0.0105s  | 1024    | 93501.4   | 0.0105s  | 1024    | 94680.75 | 0.0104s  | 1024    | 96983.47  | 0.0102s  | 1024    | 94624.62  | 0.0104s  | 1024     | 94675.416 | 0.0104s  | 1024      | 94675.416             | 0.0104s               | 1024                  | 94675.416 | 0.0104s  |          |
|   |   |   |     | FileIO --file-test-mode    | Sequential Rewrite | 19470.24 | 30.0349s | 588877  | 23994.91  | 30.0372s | 721668  | 25139.01 | 30.0312s | 752323  | 51542.65  | 30.0170s | 1545137 | 45263.53  | 30.0110s | 136373   | 33082.068 | 30.0570s | 24209.434 | 33082.068             | 30.0570s              | 24209.434             | 33082.068 | 30.0570s |          |
|   |   |   |     | FileIO --file-test-mode    | Random Read-Write  | 11330.29 | 30.0526s | 338463  | 19654.47  | 30.0467s | 94923   | 18449.53 | 30.0578s | 552506  | 13015.81  | 30.0350s | 389868  | 14848.42  | 30.0676s | 44407    | 15499.658 | 30.0578s | 13015.81  | 15499.658             | 30.0578s              | 13015.81              | 15499.658 | 30.0578s |          |

raw vs docker

| # | Image Type | RAM (-m) | CPU (-smp) | Sysbench test mode | Parameter                  | Value              | QEMU       |                       |                       | Docker     |                       |                       |
|---|------------|----------|------------|--------------------|----------------------------|--------------------|------------|-----------------------|-----------------------|------------|-----------------------|-----------------------|
|   |            |          |            |                    |                            |                    | Report     | Average Events/second | Minimum Events/second | Report     | Average Events/second | Minimum Events/second |
| 8 | qcow2      | 3        | 3          | CPU                | --cpu-max-prime            | 1000               | 391821.988 | 282523.292            | 282523.292            | 391821.988 | 282523.292            | 282523.292            |
|   |            |          |            |                    | --cpu-max-prime            | 2000               | 150087.928 | 134327.628            | 134327.628            | 150087.928 | 134327.628            | 134327.628            |
|   |            |          |            |                    | Memory --memory-block-size | 1G                 | 10.724     | 24.61                 | 24.61                 | 10.724     | 24.61                 | 24.61                 |
|   |            |          |            |                    | Memory --memory-block-size | 512K               | 88235.504  | 94675.416             | 94675.416             | 88235.504  | 94675.416             | 94675.416             |
|   |            |          |            |                    | FileIO --file-test-mode    | Sequential Rewrite | 24209.434  | 33082.068             | 33082.068             | 24209.434  | 33082.068             | 33082.068             |
|   |            |          |            |                    | FileIO --file-test-mode    | Random Read-Write  | 30108.574  | 15499.658             | 15499.658             | 30108.574  | 15499.658             | 15499.658             |

### CPU Testing Analysis: 3GB RAM with 3 CPU Cores

According to our experiment, we observe that QEMU VM is faster than Docker.

As we see, when we increase the cpu-max-prime argument value the number of events per second decreases for our current experimental configuration. QEMU is slightly faster than Docker desktop on this MacBook chip

### **Memory Testing Analysis: 3GB RAM with 3 CPU Cores**

Based on the analysis conducted using the parameters `--memory-block-size` and `-memory-total-size` in the first test case, the findings reveal that the QEMU VM outperforms Docker. Conversely, in the results of the second test case, it is observed that Docker exhibits better performance compared to the QEMU VM.

### **FileIO Testing Analysis: 3GB RAM with 3 CPU Cores**

As per the results of both test cases, for sequential rewrite operations, Docker Desktop is faster than QEMU, but QEMU is faster in case of and combined random read/write operations.

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## **Performance Analysis**

### **Disk Utilization**

QEMU (qcow2)

|                            |                            |                                               |
|----------------------------|----------------------------|-----------------------------------------------|
| <b>2GB RAM 2 CPU Cores</b> | Sequential Rewrite         | read, MiB/s: 0.00<br>written, MiB/s: 340.33   |
|                            | Combined Random Read Write | read, MiB/s: 274.21<br>written, MiB/s: 182.81 |
| <b>2GB RAM 3 CPU Cores</b> | Sequential Rewrite         | read, MiB/s: 0.00<br>written, MiB/s: 189.43   |
|                            | Combined Random Read Write | read, MiB/s: 111.97<br>written, MiB/s: 74.64  |
| <b>3GB RAM 2 CPU Cores</b> | Sequential Rewrite         | read, MiB/s: 0.00<br>written, MiB/s: 175.62   |
|                            | Combined Random Read Write | read, MiB/s: 102.03<br>written, MiB/s: 68.02  |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | read, MiB/s: 0.00<br>written, MiB/s: 162.85   |
|                            | Combined Random Read Write | read, MiB/s: 112.14<br>written, MiB/s: 74.75  |

QEMU (raw)

|                            |                    |                   |
|----------------------------|--------------------|-------------------|
| <b>2GB RAM 2 CPU Cores</b> | Sequential Rewrite | read, MiB/s: 0.00 |
|----------------------------|--------------------|-------------------|

|                            |                            |                 |        |
|----------------------------|----------------------------|-----------------|--------|
|                            |                            | written, MiB/s: | 330.96 |
|                            | Combined Random Read Write | read, MiB/s:    | 242.53 |
| <b>2GB RAM 3 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 161.68 |
|                            | Combined Random Read Write | read, MiB/s:    | 0.00   |
| <b>3GB RAM 2 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 263.94 |
|                            | Combined Random Read Write | read, MiB/s:    | 44.29  |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 29.52  |
|                            | Combined Random Read Write | read, MiB/s:    | 0.00   |
| <b>3GB RAM 2 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 176.42 |
|                            | Combined Random Read Write | read, MiB/s:    | 105.32 |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 70.21  |
|                            | Combined Random Read Write | read, MiB/s:    | 0.00   |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 168.53 |
|                            | Combined Random Read Write | read, MiB/s:    | 126.89 |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | written, MiB/s: | 84.60  |

## Docker

|                            |                            |                 |        |
|----------------------------|----------------------------|-----------------|--------|
|                            | Sequential Rewrite         | read, MiB/s:    | 0.00   |
|                            |                            | written, MiB/s: | 286.10 |
| <b>2GB RAM 2 CPU Cores</b> | Combined Random Read Write | read, MiB/s:    | 166.44 |
|                            |                            | written, MiB/s: | 110.95 |
| <b>2GB RAM 3 CPU Cores</b> | Sequential Rewrite         | read, MiB/s:    | 0.00   |
|                            | Combined Random Read Write | written, MiB/s: | 128.05 |
| <b>3GB RAM 2 CPU Cores</b> | Sequential Rewrite         | read, MiB/s:    | 169.84 |
|                            | Combined Random Read Write | written, MiB/s: | 113.22 |
| <b>3GB RAM 2 CPU Cores</b> | Sequential Rewrite         | read, MiB/s:    | 0.00   |
|                            | Combined Random Read Write | written, MiB/s: | 144.68 |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | read, MiB/s:    | 70.07  |
|                            | Combined Random Read Write | written, MiB/s: | 46.71  |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | read, MiB/s:    | 0.00   |
|                            | Combined Random Read Write | written, MiB/s: | 171.84 |
| <b>3GB RAM 3 CPU Cores</b> | Sequential Rewrite         | read, MiB/s:    | 75.59  |
|                            | Combined Random Read Write | written, MiB/s: | 50.39  |

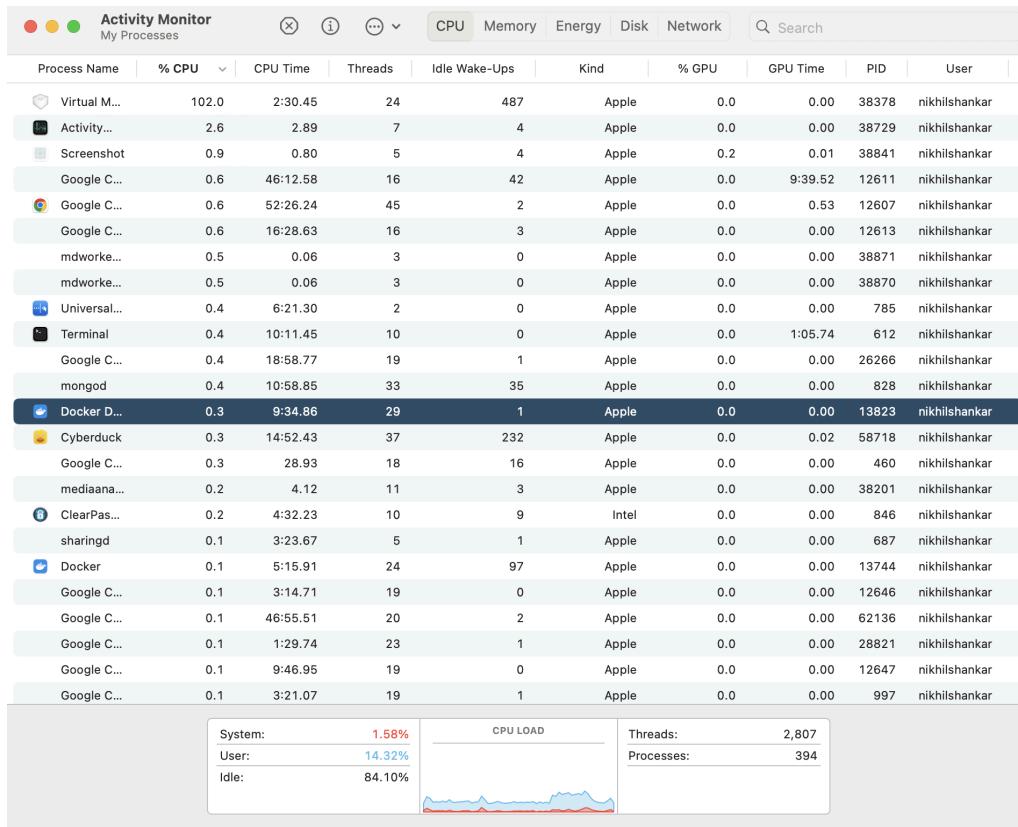
## CPU Utilization

### QEMU

| ...ntitled folder/CSEN241 — top |               |      |          |       |     |       |        |        |        |       | ...— qemu-system-aar ▾ sudo |          |  | ...emu-system-aar ▾ sudo .. |  |      |
|---------------------------------|---------------|------|----------|-------|-----|-------|--------|--------|--------|-------|-----------------------------|----------|--|-----------------------------|--|------|
| PID                             | COMMAND       | %CPU | TIME     | #TH   | #WQ | #PORT | MEM    | PURG   | CMPRS  | PGRP  | PPID                        | STATE    |  |                             |  |      |
| 372                             | WindowServer  | 15.9 | 03:35:22 | 18    | 6   | 3217- | 701M+  | 104M-  | 192M-  | 372   | 1                           | sleeping |  |                             |  | 22:0 |
| 0                               | kernel_task   | 7.4  | 03:27:28 | 484/8 | 0   | 0     | 25M+   | 0B     | 0B     | 0     | 0                           | running  |  |                             |  |      |
| 552                             | ServiceDaemon | 6.9  | 19:32.81 | 18    | 4   | 115+  | 74M+   | 0B     | 53M-   | 552   | 1                           | sleeping |  |                             |  |      |
| 38169                           | top           | 6.5  | 00:00.58 | 1/1   | 0   | 31    | 6994K+ | 0B     | 1328K  | 38169 | 92279                       | running  |  |                             |  |      |
| 38174                           | screencaptur  | 4.9  | 00:00.19 | 5     | 4   | 73    | 8226K+ | 720K   | 0B     | 627   | 627                         | sleeping |  |                             |  |      |
| 1                               | launchd       | 4.8  | 33:48.54 | 4     | 3   | 2960- | 21M    | 0B     | 2832K- | 1     | 0                           | sleeping |  |                             |  |      |
| 476                             | storagekitd   | 4.2  | 03:21.26 | 10    | 4   | 131+  | 6897K+ | 0B     | 2784K- | 476   | 1                           | sleeping |  |                             |  |      |
| 486                             | syspolicyd    | 3.9  | 05:15.91 | 4     | 2   | 158   | 21M    | 128K   | 16M-   | 486   | 1                           | sleeping |  |                             |  |      |
| 416                             | trustd        | 2.0  | 05:13.70 | 3     | 2   | 139-  | 8049K- | 256K-  | 3408K- | 416   | 1                           | sleeping |  |                             |  |      |
| 365                             | bluetoothd    | 1.8  | 28:18.52 | 10    | 4   | 366   | 22M    | 384K   | 15M    | 365   | 1                           | sleeping |  |                             |  |      |
| 374                             | tccd          | 1.4  | 04:16.68 | 4     | 3   | 61-   | 6193K  | 0B-    | 1408K- | 374   | 1                           | sleeping |  |                             |  |      |
| 555                             | mds_stores    | 1.4  | 40:34.61 | 11    | 9   | 127+  | 35M-   | 0B     | 23M-   | 555   | 1                           | sleeping |  |                             |  |      |
| 576                             | BTLEServer    | 1.3  | 09:32.06 | 2     | 1   | 48    | 2849K  | 0B     | 1360K  | 576   | 1                           | sleeping |  |                             |  |      |
| 38053                           | qemu-system-  | 1.3  | 00:11.46 | 14    | 1   | 34    | 1108M+ | 0B     | 1061M- | 38052 | 38052                       | sleeping |  |                             |  |      |
| 333                             | mds           | 1.1  | 19:57.97 | 11    | 8   | 389+  | 32M+   | 0B     | 21M-   | 333   | 1                           | sleeping |  |                             |  |      |
| 496                             | socketfilter  | 1.1  | 01:20.43 | 4     | 2   | 53    | 3937K  | 0B     | 1936K- | 496   | 1                           | sleeping |  |                             |  |      |
| 545                             | cfprefsd      | 1.0  | 01:49.46 | 3     | 2   | 339   | 4305K+ | 0B     | 1632K- | 545   | 1                           | sleeping |  |                             |  |      |
| 828                             | mongod        | 1.0  | 10:57.22 | 33    | 1   | 68    | 31M+   | 0B     | 19M-   | 828   | 1                           | sleeping |  |                             |  |      |
| 37938                           | qemu-system-  | 0.8  | 00:12.12 | 9     | 1   | 29-   | 1182M- | 0B     | 1159M- | 37937 | 37937                       | sleeping |  |                             |  |      |
| 375                             | loginwindow   | 0.7  | 02:24:45 | 6     | 2   | 702   | 72M    | 0B     | 51M    | 375   | 1                           | sleeping |  |                             |  |      |
| 304                             | logd          | 0.7  | 07:00.32 | 5     | 4   | 1210- | 28M+   | 0B     | 28M-   | 304   | 1                           | sleeping |  |                             |  |      |
| 12611                           | Google Chrom  | 0.6  | 46:01.65 | 16    | 1   | 368   | 861M   | 0B     | 109M-  | 12607 | 12607                       | sleeping |  |                             |  |      |
| 506                             | com.apple.Ap  | 0.6  | 04:36.41 | 2     | 1   | 135   | 3425K  | 0B     | 2336K  | 506   | 1                           | sleeping |  |                             |  |      |
| 12613                           | Google Chrom  | 0.5  | 16:26.40 | 16    | 1   | 217   | 66M-   | 0B     | 37M-   | 12607 | 12607                       | sleeping |  |                             |  |      |
| 38175                           | screencaptur  | 0.5  | 00:00.13 | 9     | 7   | 197   | 21M    | 4336K- | 0B     | 38175 | 1                           | sleeping |  |                             |  |      |
| 373                             | cfprefsd      | 0.5  | 01:28.91 | 3     | 2   | 544-  | 4097K  | 0B     | 1280K- | 373   | 1                           | sleeping |  |                             |  |      |
| 346                             | launchservic  | 0.5  | 02:46.03 | 6     | 5   | 450-  | 9393K  | 0B     | 2240K- | 346   | 1                           | sleeping |  |                             |  |      |
| 309                             | fsevents      | 0.5  | 06:25.95 | 15    | 1   | 172   | 7073K  | 0B     | 2640K- | 309   | 1                           | sleeping |  |                             |  |      |
| 612                             | Terminal      | 0.4  | 10:03.56 | 12    | 5   | 547   | 295M+  | 104M+  | 64M-   | 612   | 1                           | sleeping |  |                             |  |      |
| 455                             | authd         | 0.4  | 00:30.33 | 4     | 3   | 91+   | 4881K+ | 0B     | 2320K- | 455   | 1                           | sleeping |  |                             |  |      |
| 24034                           | biomed        | 0.4  | 00:00.69 | 2     | 1   | 48    | 4401K- | 0B     | 2080K- | 24034 | 1                           | sleeping |  |                             |  |      |
| 29032                           | triald        | 0.3  | 00:02.83 | 2     | 1   | 83    | 6593K  | 0B     | 5136K- | 29032 | 1                           | sleeping |  |                             |  |      |
| 31307                           | Code Helper   | 0.3  | 00:22.98 | 18    | 1   | 85    | 46M    | 0B     | 41M-   | 31281 | 31281                       | sleeping |  |                             |  |      |
| 58718                           | Cyberduck     | 0.3  | 14:49.48 | 37    | 1   | 575   | 177M   | 0B     | 165M   | 58718 | 1                           | sleeping |  |                             |  |      |
| 336                             | diskarbitrat  | 0.3  | 00:33.88 | 2     | 1   | 257-  | 3377K- | 0B     | 1552K- | 336   | 1                           | sleeping |  |                             |  |      |
| 38124                           | CommCenter    | 0.2  | 00:00.14 | 9     | 5   | 164   | 6433K  | 0B     | 3552K- | 38124 | 1                           | sleeping |  |                             |  |      |
| 411                             | analyticsd    | 0.2  | 00:27.52 | 3     | 2   | 472-  | 6449K- | 512K+  | 3680K- | 411   | 1                           | sleeping |  |                             |  |      |
| 366                             | notifyd       | 0.2  | 01:23.65 | 3     | 2   | 634-  | 3473K  | 0B     | 1072K- | 366   | 1                           | sleeping |  |                             |  |      |
| 316                             | configd       | 0.2  | 03:13.55 | 7     | 1   | 587-  | 6817K- | 0B     | 3568K- | 316   | 1                           | sleeping |  |                             |  |      |
| 12607                           | Google Chrom  | 0.2  | 52:10.96 | 45    | 1   | 2192  | 385M   | 0B     | 279M-  | 12607 | 1                           | sleeping |  |                             |  |      |
| 38152                           | mdworker_sha  | 0.1  | 00:00.06 | 3     | 1   | 51    | 3857K  | 0B     | 2032K- | 38152 | 1                           | sleeping |  |                             |  |      |
| 377                             | runningboard  | 0.1  | 03:22.00 | 8     | 7   | 404   | 8129K  | 0B     | 1744K- | 377   | 1                           | sleeping |  |                             |  |      |
| 481                             | oahd          | 0.1  | 00:51.85 | 3     | 2   | 31    | 1921K  | 0B     | 992K-  | 481   | 1                           | sleeping |  |                             |  |      |
| 3532                            | sandboxd      | 0.1  | 00:29.64 | 4     | 3   | 44+   | 3825K+ | 0B     | 1568K- | 3532  | 1                           | sleeping |  |                             |  |      |
| 624                             | Dock          | 0.1  | 01:14.19 | 4     | 2   | 1147  | 49M    | 0B     | 49M-   | 624   | 1                           | sleeping |  |                             |  |      |
| 628                             | Finder        | 0.1  | 09:37.76 | 8     | 4   | 816   | 258M   | 0B     | 228M-  | 628   | 1                           | sleeping |  |                             |  |      |
| 80772                           | com.apple.Am  | 0.1  | 00:39.97 | 3     | 1   | 76    | 3841K  | 0B     | 2592K  | 80772 | 1                           | sleeping |  |                             |  |      |
| 368                             | corebrightne  | 0.1  | 03:23.80 | 4     | 3   | 129   | 4049K  | 0B     | 2480K  | 368   | 1                           | sleeping |  |                             |  |      |
| 846                             | ClearPass On  | 0.0  | 04:31.57 | 7     | 1   | 192   | 25M    | 0B     | 21M    | 846   | 1                           | sleeping |  |                             |  |      |
| 722                             | Spotlight     | 0.0  | 00:59.63 | 4     | 1   | 714   | 116M   | 0B     | 108M-  | 722   | 1                           | sleeping |  |                             |  |      |
| 13744                           | com.docker.b  | 0.0  | 05:15.04 | 25    | 1   | 265   | 121M   | 0B     | 119M   | 13744 | 1                           | sleeping |  |                             |  |      |
| 78234                           | PerfPowerSer  | 0.0  | 00:46.92 | 5     | 2   | 496-  | 14M-   | 0B     | 7696K- | 78234 | 1                           | sleeping |  |                             |  |      |
| 29086                           | callservices  | 0.0  | 00:01.55 | 7     | 4   | 410   | 12M    | 0B     | 7808K- | 29086 | 1                           | sleeping |  |                             |  |      |
| 344                             | opendirector  | 0.0  | 02:47.21 | 10    | 9   | 969-  | 12M-   | 0B     | 6544K- | 344   | 1                           | sleeping |  |                             |  |      |

## Docker

| ...3:/logs updated-base-image ...                           |                                                                            |            | ~ -- top                            |       |     | ~ -- -zsh |        |       |
|-------------------------------------------------------------|----------------------------------------------------------------------------|------------|-------------------------------------|-------|-----|-----------|--------|-------|
| Processes: 386 total, 3 running, 383 sleeping, 2838 threads |                                                                            |            |                                     |       |     |           |        |       |
| Load Avg:                                                   | 2.27, 1.97, 1.92                                                           | CPU usage: | 15.48% user, 5.64% sys, 78.87% idle |       |     |           |        | 22:   |
| SharedLibs:                                                 | 245M resident, 56M data, 16M linkedit.                                     |            |                                     |       |     |           |        |       |
| MemRegions:                                                 | 414655 total, 1585M resident, 75M private, 1755M shared.                   |            |                                     |       |     |           |        |       |
| PhysMem:                                                    | 7412M used (1582M wired, 2093M compressor), 86M unused.                    |            |                                     |       |     |           |        |       |
| VM:                                                         | 179T vsiz, 4769M framework vsiz, 3679181(28) swapins, 4412016(0) swapouts. |            |                                     |       |     |           |        |       |
| Networks:                                                   | packets: 4491988/3907M in, 2366116/1115M out.                              |            |                                     |       |     |           |        |       |
| Disks:                                                      | 51854131/13496 read, 30899061/1825G written.                               |            |                                     |       |     |           |        |       |
| PID                                                         | COMMAND                                                                    | %CPU       | TIME                                | #TH   | #WQ | #PORT     | MEM    | PURG  |
| 38378                                                       | com.apple.Vi                                                               | 100.7      | 00:34.02                            | 26/1  | 4   | 85        | 1034M  | 0B    |
| 0                                                           | kernel_task                                                                | 10.3       | 03:27:41                            | 484/8 | 0   | 0         | 24M    | 0B    |
| 372                                                         | WindowServer                                                               | 9.0        | 03:35:42                            | 17    | 5   | 3229+     | 683M-  | 77M+  |
| 997                                                         | Google Chrom                                                               | 4.2        | 03:20.17                            | 19    | 1   | 396       | 350M+  | 0B    |
| 38447                                                       | top                                                                        | 4.1        | 00:00.86                            | 1/1   | 0   | 30        | 7361K- | 0B    |
| 12646                                                       | Google Chrom                                                               | 4.0        | 03:14.54                            | 19    | 1   | 281       | 168M+  | 0B    |
| 15191                                                       | Google Chrom                                                               | 3.3        | 09:27.51                            | 19    | 1   | 220       | 152M+  | 0B    |
| 12641                                                       | Google Chrom                                                               | 3.2        | 05:42.86                            | 20    | 1   | 292       | 373M+  | 0B    |
| 26266                                                       | Google Chrom                                                               | 3.1        | 18:48.13                            | 22    | 1   | 451       | 367M+  | 0B    |
| 12647                                                       | Google Chrom                                                               | 3.0        | 09:46.74                            | 19    | 1   | 349       | 248M+  | 0B    |
| 12636                                                       | Google Chrom                                                               | 2.5        | 04:03.48                            | 18    | 1   | 320       | 219M   | 0B    |
| 90706                                                       | Google Chrom                                                               | 2.5        | 01:20.67                            | 19    | 1   | 348       | 303M-  | 0B    |
| 38489                                                       | screencaptur                                                               | 2.2        | 00:00.19                            | 5     | 4   | 73        | 8226K  | 752K  |
| 1020                                                        | SophosMcsAge                                                               | 1.8        | 17:14.34                            | 45    | 44  | 162+      | 9682K+ | 0B    |
| 365                                                         | bluetoothd                                                                 | 1.7        | 28:21.18                            | 11    | 5   | 363       | 22M    | 384K  |
| 12613                                                       | Google Chrom                                                               | 1.3        | 16:27.29                            | 16    | 1   | 218       | 67M+   | 0B    |
| 12607                                                       | Google Chrom                                                               | 0.9        | 52:17.34                            | 46    | 2   | 2197      | 385M+  | 0B    |
| 1                                                           | launchd                                                                    | 0.8        | 33:50.42                            | 4     | 3   | 2999      | 21M    | 0B    |
| 443                                                         | mDNSResponde                                                               | 0.7        | 08:45.09                            | 4     | 2   | 126       | 6145K  | 0B    |
| 822                                                         | SophosConfig                                                               | 0.6        | 08:17.55                            | 7     | 5   | 254       | 11M    | 0B    |
| 12611                                                       | Google Chrom                                                               | 0.6        | 46:06.23                            | 16    | 1   | 369       | 824M   | 0B    |
| 576                                                         | BTLEServer                                                                 | 0.6        | 09:33.39                            | 2     | 1   | 48        | 2849K  | 0B    |
| 12653                                                       | Google Chrom                                                               | 0.5        | 00:30.42                            | 19    | 1   | 187       | 94M    | 0B    |
| 28821                                                       | Google Chrom                                                               | 0.4        | 01:29.56                            | 23    | 1   | 237       | 225M+  | 0B    |
| 679                                                         | nearbyd                                                                    | 0.3        | 02:27.55                            | 9     | 7   | 99        | 5346K  | 0B    |
| 828                                                         | mongod                                                                     | 0.3        | 10:57.89                            | 33    | 1   | 68        | 30M    | 0B    |
| 612                                                         | Terminal                                                                   | 0.3        | 10:08.78                            | 10    | 3   | 549       | 274M-  | 104M- |
| 506                                                         | com.apple.Ap                                                               | 0.2        | 04:37.07                            | 2     | 1   | 135       | 3425K  | 0B    |
| 460                                                         | Google Chrom                                                               | 0.2        | 00:27.84                            | 18    | 1   | 171       | 149M   | 0B    |
| 58718                                                       | Cyberduck                                                                  | 0.2        | 14:50.71                            | 37    | 1   | 577       | 177M   | 0B    |
| 38490                                                       | screencaptur                                                               | 0.2        | 00:00.11                            | 11    | 9   | 202       | 21M    | 36M   |
| 13744                                                       | com.docker.b                                                               | 0.2        | 05:15.45                            | 25    | 1   | 271       | 125M   | 0B    |
| 687                                                         | sharingd                                                                   | 0.2        | 03:23.41                            | 4     | 1   | 364       | 21M    | 0B    |
| 351                                                         | locationd                                                                  | 0.1        | 04:32.63                            | 5     | 3   | 263       | 7969K  | 0B    |
| 628                                                         | Finder                                                                     | 0.1        | 09:38.24                            | 8     | 4   | 821       | 257M   | 0B    |
| 62136                                                       | Google Chrom                                                               | 0.1        | 46:37.14                            | 19    | 1   | 383       | 426M   | 0B    |
| 60556                                                       | com.apple.ap                                                               | 0.1        | 02:22.84                            | 4     | 2   | 383+      | 89M+   | 0B    |
| 309                                                         | fsevents                                                                   | 0.1        | 06:26.22                            | 15    | 1   | 174+      | 6929K+ | 0B    |
| 539                                                         | searchpartyd                                                               | 0.1        | 09:18.26                            | 7     | 6   | 108       | 7922K  | 384K  |
| 316                                                         | configd                                                                    | 0.1        | 03:13.72                            | 8     | 2   | 593+      | 6865K+ | 0B    |
| 368                                                         | corebrightne                                                               | 0.1        | 03:24.00                            | 3     | 2   | 129       | 4017K  | 0B    |
| 80772                                                       | com.apple.Am                                                               | 0.0        | 00:40.13                            | 3     | 1   | 76        | 3825K  | 0B    |
| 304                                                         | logd                                                                       | 0.0        | 07:00.78                            | 5     | 4   | 1268      | 28M    | 0B    |
| 846                                                         | ClearPass On                                                               | 0.0        | 04:31.87                            | 7     | 1   | 194       | 25M    | 0B    |
| 356                                                         | distnoted                                                                  | 0.0        | 01:22.59                            | 2     | 1   | 166       | 7329K  | 0B    |
| 491                                                         | audioclocksy                                                               | 0.0        | 01:40.53                            | 4     | 3   | 46        | 6529K  | 0B    |
| 329                                                         | watchdogd                                                                  | 0.0        | 00:05.35                            | 3     | 1   | 51        | 1793K  | 0B    |
| 625                                                         | fileprovider                                                               | 0.0        | 03:15.44                            | 4     | 3   | 180       | 21M    | 0B    |
| 549                                                         | OnGuardServ                                                                | 0.0        | 01:38.86                            | 8     | 1   | 47        | 7895K  | 0B    |
| 78234                                                       | PerfPowerSer                                                               | 0.0        | 00:47.09                            | 5     | 2   | 493-      | 14M-   | 0B    |
| 344                                                         | opendirector                                                               | 0.0        | 02:47.44                            | 8     | 7   | 1038      | 12M    | 0B    |
| 552                                                         | ServiceDaemo                                                               | 0.0        | 19:33.89                            | 17    | 3   | 114       | 70M    | 0B    |
| 333                                                         | mds                                                                        | 0.0        | 19:58.38                            | 10    | 7   | 407       | 32M    | 0B    |
| 349                                                         | securityd                                                                  | 0.0        | 00:33.61                            | 4     | 1   | 126       | 7457K  | 0B    |



## Git Repository Details

|                 |                                                                                                                                                                                                |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Account Name    | inchrndr                                                                                                                                                                                       |
| Repository Name | CSEN241                                                                                                                                                                                        |
| Repository Link | <a href="https://github.com/iraveendra/CSEN241">https://github.com/iraveendra/CSEN241</a><br><a href="https://github.com/iraveendra/CSEN241.git">https://github.com/iraveendra/CSEN241.git</a> |
| Commit ID       | 959d7be9d2ee025863f6d6f947f3f000e6b615d5                                                                                                                                                       |