

Mini Project 1: Containers and Virtual VMs

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1. VM Instance Configuration Details

The VM-instance is created using the provided instructions and specified OS version (Ubuntu Bionic Beaver (18.04) with 30 GB disk space is enabled.

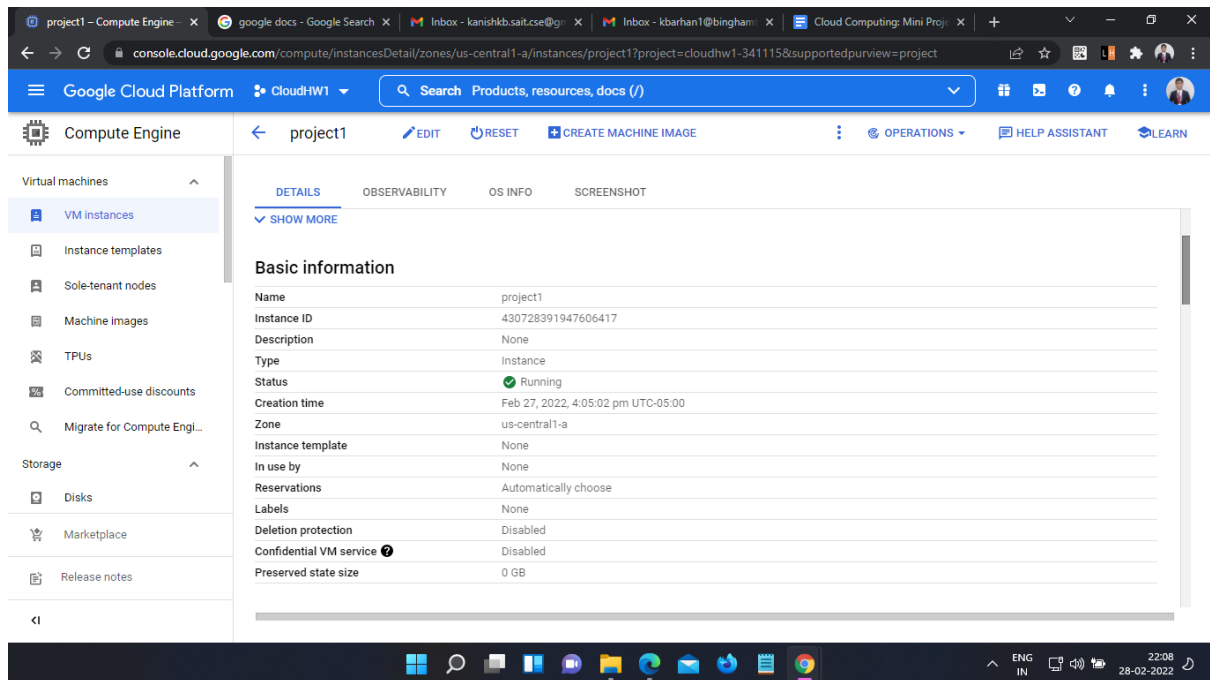


Figure 1: Basic Information about the created VM-instance “project1”.

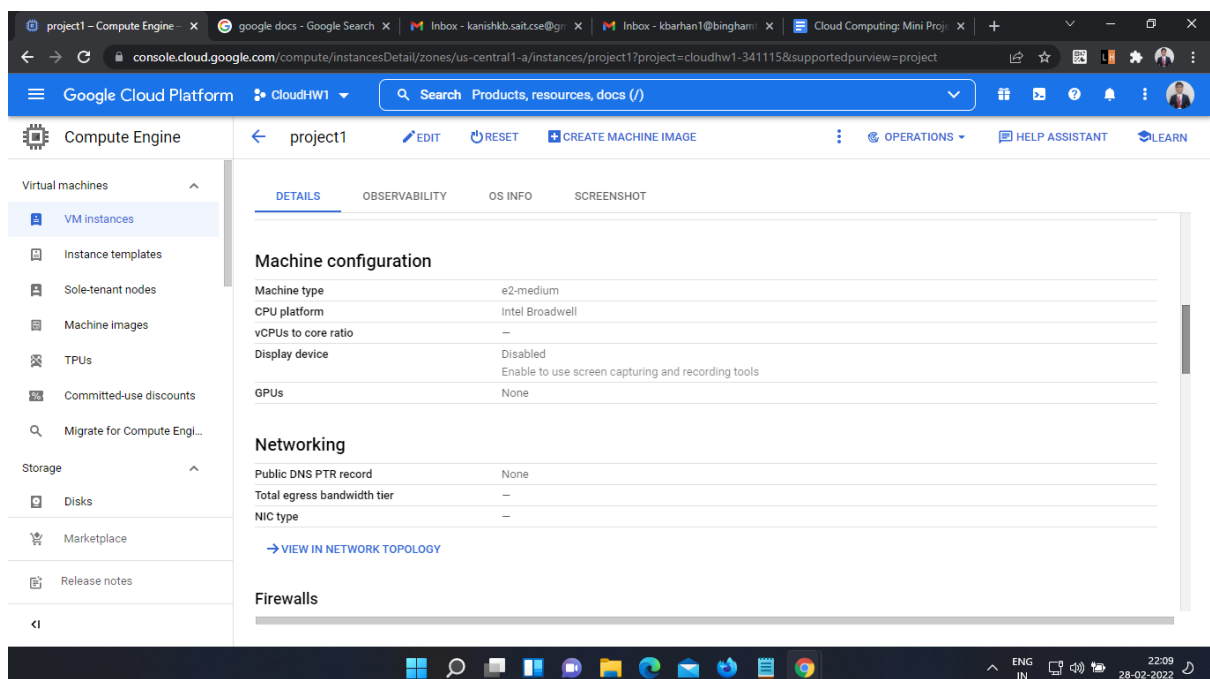


Figure 2: Machine configuration for the VM-instance “project1”.

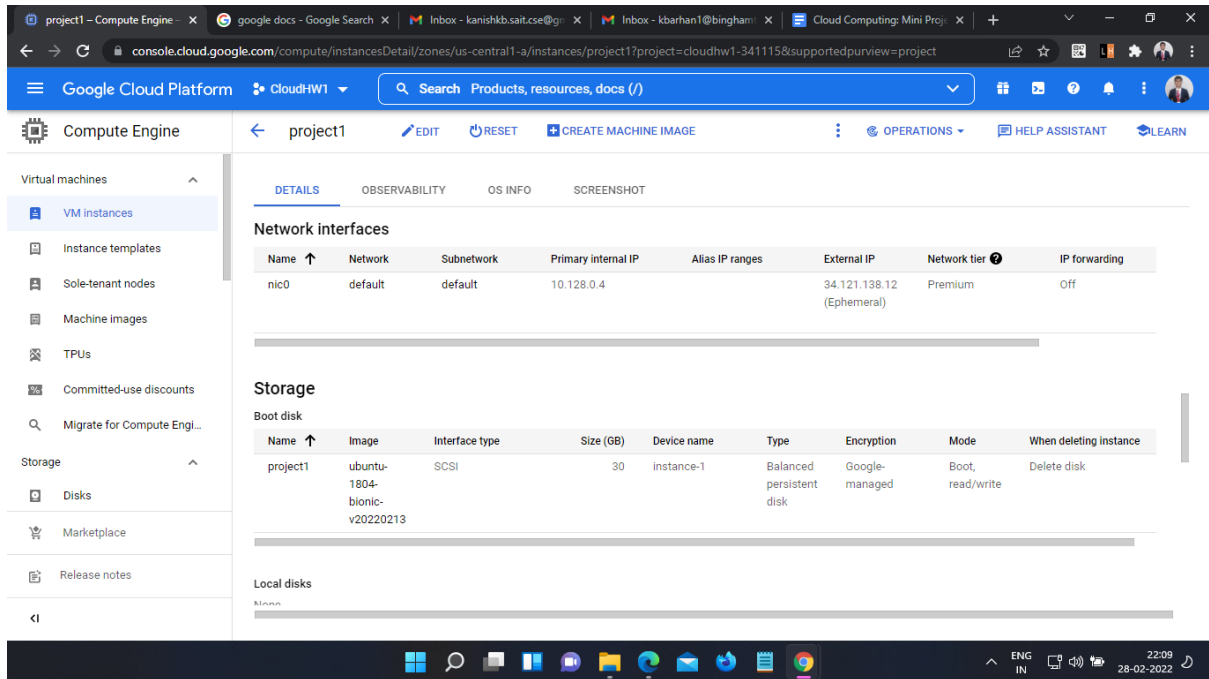


Figure 3: Storage and network interfaces details for the VM-instance “project1”.

2. Docker Basics

The Docker has been installed in the VM-instance “project1” and basic commands are performed to understand the basics of Docker.

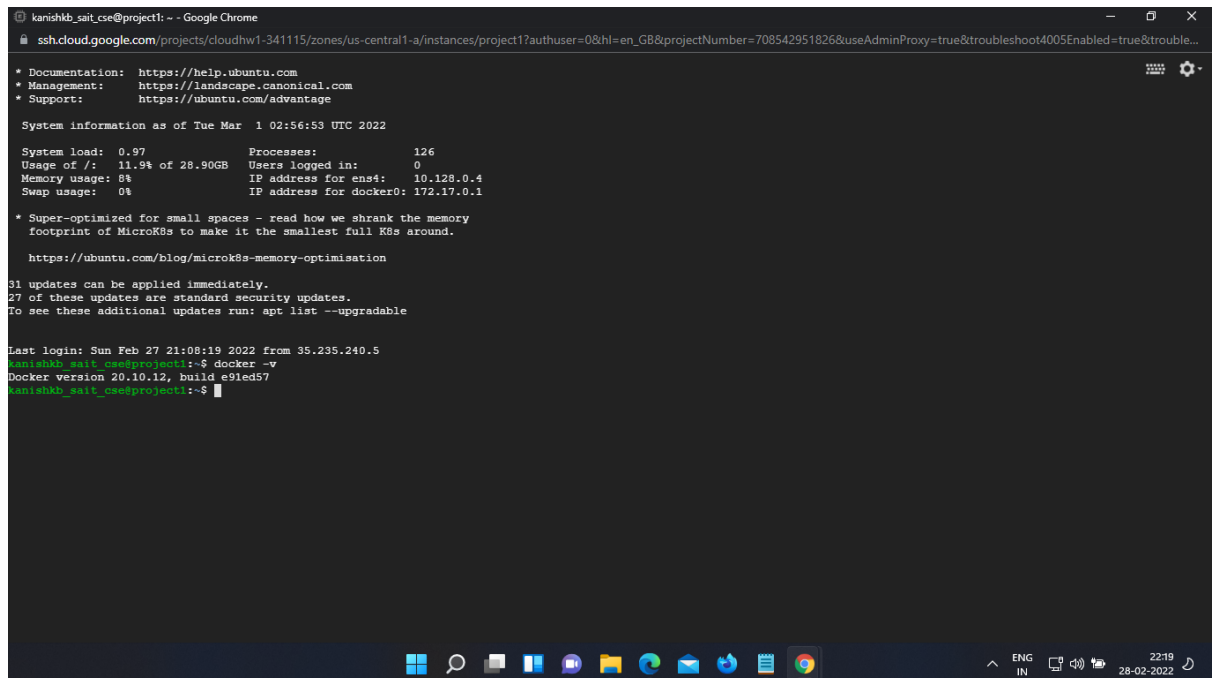


Figure 4: Command “docker -v” output to show that Docker installation.

```
kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhwl-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@project1:~$ docker pull alpine
Using default tag: latest
Got permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock: Post "http://%2Fvar%2Frun%2Fdocker.sock/v1.24/images/create?fromImage=-alpine&tag=latest": dial unix /var/run/docker.sock: connect: permission denied
kanishkb_sait_cse@project1:~$ sudo docker pull alpine
Using default tag: latest
latest: Pulling from library/alpine
Digest: sha256:21a3deaa0d32a8057914f36584b5288d2e5ecc984380bc0118285c70fa8c9300
Status: Image is up to date for alpine:latest
docker.io/library/alpine:latest
kanishkb_sait_cse@project1:~$ sudo docker run alpine ls -l
total 56
drwxr-xr-x 2 root root 4096 Nov 24 09:20 bin
drwxr-xr-x 5 root root 340 Mar 1 03:26 dev
drwxr-xr-x 1 root root 4096 Mar 1 03:26 etc
drwxr-xr-x 2 root root 4096 Nov 24 09:20 home
drwxr-xr-x 7 root root 4096 Nov 24 09:20 lib
drwxr-xr-x 5 root root 4096 Nov 24 09:20 media
drwxr-xr-x 2 root root 4096 Nov 24 09:20 mnt
drwxr-xr-x 2 root root 4096 Nov 24 09:20 opt
dr-xr-xr-x 180 root root 0 Mar 1 03:26 proc
drwxr-xr-x 2 root root 4096 Nov 24 09:20 root
drwxr-xr-x 2 root root 4096 Nov 24 09:20 run
drwxr-xr-x 2 root root 4096 Nov 24 09:20/sbin
drwxr-xr-x 2 root root 4096 Nov 24 09:20/srv
dr-xr-xr-x 13 root root 0 Mar 1 03:26 sys
drwxrwxrwt 2 root root 4096 Nov 24 09:20 tmp
drwxr-xr-x 7 root root 4096 Nov 24 09:20 usr
drwxr-xr-x 12 root root 4096 Nov 24 09:20 var
kanishkb_sait_cse@project1:~$
```

Figure 5: Docker and “alpine” as first container.

To run the first container and understand the set of commands associated with Docker, Alpine Container has been launched and then runs a command in Docker.

```
kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhwl-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@project1:~$ docker run alpine echo "hello from alpine"
docker: Got permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock: Post "http://%2Fvar%2Frun%2Fdocker.sock/v1.24/containers/create?name=hello-from-alpine": dial unix /var/run/docker.sock: connect: permission denied.
See 'docker run --help'.
kanishkb_sait_cse@project1:~$ sudo docker run alpine echo "hello from alpine"
hello from alpine
kanishkb_sait_cse@project1:~$ sudo docker run alpine /bin/sh
Got permission denied while trying to connect to the Docker daemon socket at unix:///var/run/docker.sock: Get "http://%2Fvar%2Frun%2Fdocker.sock/v1.24/containers/json?all=1": dial unix /var/run/docker.sock: connect: permission denied
kanishkb_sait_cse@project1:~$ sudo docker ps -a
CONTAINER ID   IMAGE     COMMAND                  CREATED              STATUS              PORTS          NAMES
a87098624ec8   alpine    "/bin/sh"                35 seconds ago      Exited (0) 34 seconds ago          crazy_ptolcmv
57d0fda1d07    alpine    "echo 'hello from al..." About a minute ago   Exited (0) 59 seconds ago          exciting_curren
64f4da391a5d   alpine    "ls -l"                  2 minutes ago       Exited (0) 2 minutes ago          happy_turing
a78ca2995781   alpine    "echo 'hello from al..." 30 hours ago         Exited (0) 30 hours ago          dreamy_gagarin
c51c6b49ba9d   alpine    "ls -l"                  30 hours ago         Exited (0) 30 hours ago          jovial_ritchie
3e8ec6fff091   hello-world "/hello"                 30 hours ago         Exited (0) 30 hours ago          affectionate_gould
kanishkb_sait_cse@project1:~$ sudo docker run -it alpine /bin/sh
/ #
```

Figure 6: Different commands associated with Docker Alpine container.

3. QEMU Installation

```
kanishkb_sait_cse@projectl: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhwl-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@projectl:~$ sudo apt-get install qemu
Reading package lists... Done
Building dependency tree
Reading state information... Done
qemu is already the newest version (1:2.11+dfsg-lubuntu7.39).
0 upgraded, 0 newly installed, 0 to remove and 4 not upgraded.
kanishkb_sait_cse@projectl:~$ sudo qemu-system-x86_64 --version
QEMU emulator version 2.11.1(Debian 1:2.11+dfsg-lubuntu7.39)
Copyright (c) 2003-2017 Fabrice Bellard and the QEMU Project developers
kanishkb_sait_cse@projectl:~$
```

Figure 7: Commands to check about QEMU is installed.

```
kanishkb_sait_cse@projectl: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhwl-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@projectl:~$ sudo apt-get install qemu
Reading package lists... Done
Building dependency tree
Reading state information... Done
qemu is already the newest version (1:2.11+dfsg-lubuntu7.39).
0 upgraded, 0 newly installed, 0 to remove and 4 not upgraded.
kanishkb_sait_cse@projectl:~$ sudo qemu-system-x86_64 --version
QEMU emulator version 2.11.1(Debian 1:2.11+dfsg-lubuntu7.39)
Copyright (c) 2003-2017 Fabrice Bellard and the QEMU Project developers
kanishkb_sait_cse@projectl:~$ wget http://mirror.pnl.gov/releases/18.04/ubuntu-18.04.6-live-server-amd64.iso
--2022-03-01 03:42:46-- http://mirror.pnl.gov/releases/18.04/ubuntu-18.04.6-live-server-amd64.iso
Resolving mirror.pnl.gov (mirror.pnl.gov)... 192.101.102.2
Connecting to mirror.pnl.gov (mirror.pnl.gov)|192.101.102.2|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 1016070144 (969M) [application/octet-stream]
Saving to: 'ubuntu-18.04.6-live-server-amd64.iso'

ubuntu-18.04.6-live-server-amd64.iso 100%[=====>] 969.00M 51.3MB/s in 25s

2022-03-01 03:43:11 (38.6 MB/s) - 'ubuntu-18.04.6-live-server-amd64.iso' saved [1016070144/1016070144]

kanishkb_sait_cse@projectl:~$ sudo qemu-img create ubuntu.img 10G
Formatting 'ubuntu.img', fmt=raw size=10737418240
kanishkb_sait_cse@projectl:~$
```

Figure 8: Commands to check about QEMU is installed.

```
kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@project1:~$ sudo apt-get install qemu
Reading package lists... Done
Building dependency tree
Reading state information... Done
qemu is already the newest version (1:2.11+dfsg-lubuntu7.39).
0 upgraded, 0 newly installed, 0 to remove and 4 not upgraded.
kanishkb_sait_cse@project1:~$ sudo qemu-system-x86_64 --version
QEMU emulator version 2.11.1(Debian 1:2.11+dfsg-lubuntu7.39)
Copyright (c) 2003-2017 Fabrice Bellard and the QEMU Project developers
kanishkb_sait_cse@project1:~$ wget http://mirror.pnl.gov/releases/18.04/ubuntu-18.04.6-live-server-amd64.iso
--2022-03-01 03:42:46-- http://mirror.pnl.gov/releases/18.04/ubuntu-18.04.6-live-server-amd64.iso
Resolving mirror.pnl.gov (mirror.pnl.gov)... 192.101.102.2
Connecting to mirror.pnl.gov (mirror.pnl.gov)|192.101.102.2|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 1016070144 (969M) [application/octet-stream]
Saving to: 'ubuntu-18.04.6-live-server-amd64.iso'

ubuntu-18.04.6-live-server-amd64.iso 100%[=====>] 969.00M 51.3MB/s in 25s

2022-03-01 03:43:11 (38.6 MB/s) - 'ubuntu-18.04.6-live-server-amd64.iso' saved [1016070144/1016070144]

kanishkb_sait_cse@project1:~$ sudo qemu-img create ubuntu.img 10G
Formatting 'ubuntu.img', fmt=raw size=10737418240
kanishkb_sait_cse@project1:~$
```

Figure 9: To create an image before installation for QEMU VM.

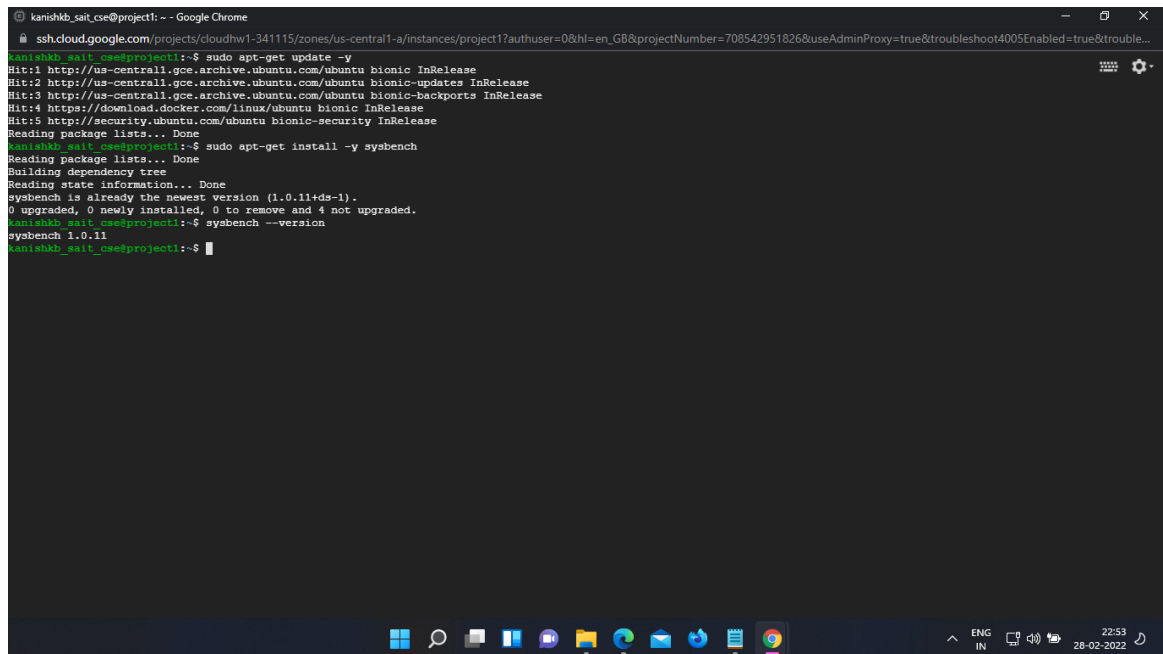
The following commands are performed for QEMU installation

- \$sudo apt-get update
- \$sudo apt-get install qemu
- \$wget http://mirror.pnl.gov/releases/18.04/ubuntu-18.04.6-live-server-amd64.iso
- \$sudo qemu-img create ubuntu.img 10G

To enable the QEMU VM following commands are used-

- \$sudo apt-get update
- \$sudo apt-get install gnome-core
- \$sudo apt-get install gnome-panel
- \$sudo apt-get install vnc4server
- \$vncserver

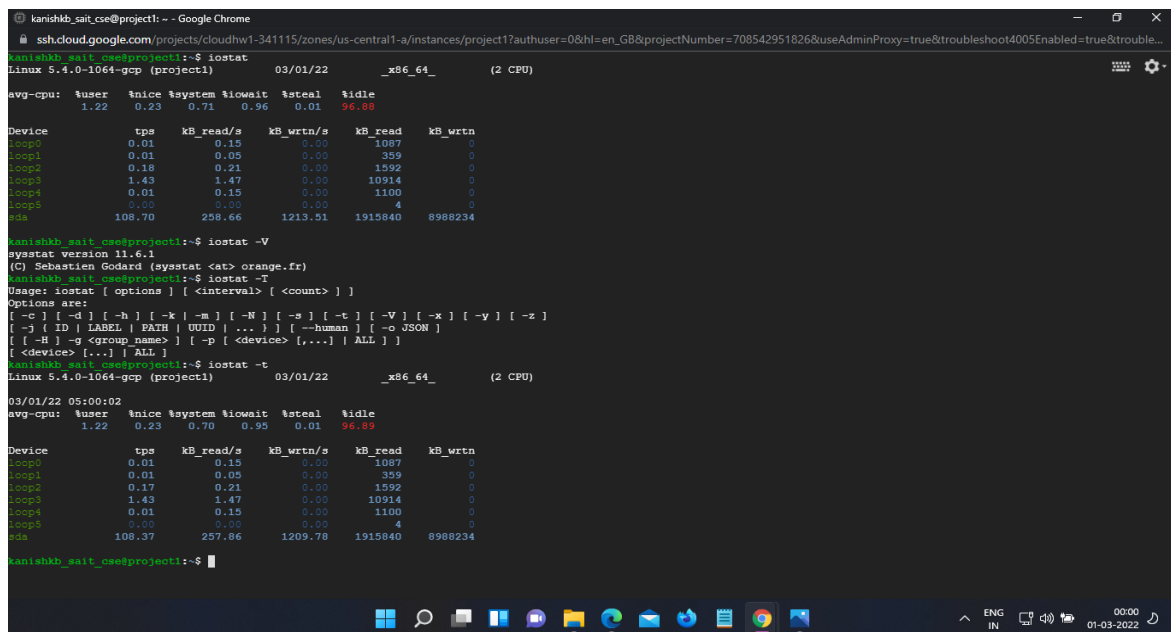
4. Sysbench Installation



```
kanishk_sait_cse@project1:~$ sudo apt-get update -y
Hit:1 http://us-central1-gce.archive.ubuntu.com/ubuntu bionic InRelease
Hit:2 http://us-central1-gce.archive.ubuntu.com/ubuntu bionic-updates InRelease
Hit:3 http://us-central1-gce.archive.ubuntu.com/ubuntu bionic-backports InRelease
Hit:4 https://download.docker.com/linux/ubuntu bionic InRelease
Hit:5 http://security.ubuntu.com/ubuntu bionic-security InRelease
Reading package lists... Done
kanishk_sait_cse@project1:~$ sudo apt-get install -y sysbench
Reading package lists... Done
Building dependency tree
Reading state information... Done
sysbench is already the newest version (1.0.11+ds-1).
0 upgraded, 0 newly installed, 0 to remove and 4 not upgraded.
kanishk_sait_cse@project1:~$ sysbench --version
sysbench 1.0.11
kanishk_sait_cse@project1:~$
```

Figure 10: Status of Sysbench installation.

5. Iostat installation and basic operations



```
kanishk_sait_cse@project1:~$ iostat
Linux 5.4.0-1064-gcp (project1)      03/01/22      _x86_64_      (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.22    0.23    0.71    0.96    0.01   96.89

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loopr              0.01         0.15         0.00       1087         0
loopl              0.01         0.05         0.00        359         0
loop2              0.18         0.21         0.00       1592         0
loop3              1.43         1.47         0.00      10914         0
loop4              0.01         0.15         0.00       1100         0
loop5              0.00         0.00         0.00         4         0
sda               108.70        258.66       1213.51     1915840     8988234

kanishk_sait_cse@project1:~$ iostat -V
sysstat version 11.6.1
(C) Sebastien Godard (sysstat <at> orange.fr)
kanishk_sait_cse@project1:~$ iostat -t
Usage: iostat [ options ] [ <interval> [ <count> ] ]
Options are:
[-c] [-d] [-h] [-k] [-m] [-N] [-s] [-t] [-V] [-x] [-y] [-z]
[-j] [ ID | LABEL | PATH | UUID | ... ] [--human] [-o JSON]
[ [-H] -g <group name> ] [-p [ <device> [,...] | ALL ] ]
[ <devices> [...] | ALL ]
kanishk_sait_cse@project1:~$ iostat -t
Linux 5.4.0-1064-gcp (project1)      03/01/22      _x86_64_      (2 CPU)

03/01/22 05:00:02
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.22    0.23    0.70    0.95    0.01   96.89

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loopr              0.01         0.15         0.00       1087         0
loopl              0.01         0.05         0.00        359         0
loop2              0.17         0.21         0.00       1592         0
loop3              1.43         1.47         0.00      10914         0
loop4              0.01         0.15         0.00       1100         0
loop5              0.00         0.00         0.00         4         0
sda               108.37        257.86       1209.78     1915840     8988234

kanishk_sait_cse@project1:~$
```

Figure 11: Iostat basic operations.

6. Sysbench CPU performance testing (inside Docker)

[Run 3 times; results attached for 1 iteration]

```
root@d778e5fc21d8: / - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

root@d778e5fc21d8:~# sudo docker run -it --runtime=runc csminpp/ubuntu-sysbench /bin/bash
sysbench 0.4.12: multi-threaded system evaluation benchmark

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

Doing CPU performance benchmark

Threads started!
Done.

Maximum prime number checked in CPU test: 30000

Test execution summary:
total time: 47.5176s
total number of events: 10000
total time taken by event execution: 47.5157
per-request statistics:
  min: 4.60ms
  avg: 4.75ms
  max: 11.33ms
  approx. 95 percentile: 4.85ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 47.5157/0.00

root@d778e5fc21d8:~# df -h
Filesystem      Size  Used Avail Use% Mounted on
overlay          29G   4.8G   25G  17% /
tmpfs            64M    0   64M   0% /dev
tmpfs            2.0G    0   2.0G   0% /sys/fs/cgroup
shm             64M    0   64M   0% /dev/shm
/dev/sda1        29G   4.8G   25G  17% /etc/hosts
tmpfs            2.0G    0   2.0G   0% /proc/acpi
tmpfs            2.0G    0   2.0G   0% /proc/scsi
tmpfs            2.0G    0   2.0G   0% /sys/firmware
root@d778e5fc21d8:~#
```

Figure 12: Output for following commands-

- `$sudo docker run -it --runtime=runc csminpp/ubuntu-sysbench /bin/bash`
- `$sysbench --test=cpu --cpu-max-prime=30000 run`
- `$df -h`

```
kanishb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

Linux 5.4.0-1064-gcp (project1) 03/01/22 _x86_64_ (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.53    0.13    0.47    0.59    0.01   97.26

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop1              0.01         0.09         0.00       1087         0
loop2              0.00         0.03         0.00        359         0
loop3              0.10         0.13         0.00       1592         0
loop4              0.85         0.88         0.00      10914         0
loop5              0.01         0.09         0.00       1100         0
loop6              0.00         0.00         0.00         4         0
loop7              0.00         0.00         0.00         0         0
loop8              0.00         0.00         0.00         0         0
sda                65.30       155.15       779.26    1928508    9685894

kanishb_sait_cse@project1:~# iostat -c 15
Linux 5.4.0-1064-gcp (project1) 03/01/22 _x86_64_ (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.53    0.13    0.47    0.59    0.01   97.27

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.07    0.00    0.00    0.00    0.00   99.93

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.03    0.00    0.00    0.00    0.00   99.97

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           2.00    0.00    0.63    0.03    0.00   97.33

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.07    0.00    0.00    0.00    0.00   99.93

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.07    0.00    4.54   11.12    0.03   83.24
```

Figure 13: Output for the following commands-

- `$iostat ALL`
- `$iostat -c 15`

```
kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@project1:~$ mpstat 1
Linux 5.4.0-1064-gcp (project1)      03/01/22      _x86_64_      (2 CPU)

06:27:36  CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %gnice   %idle
06:27:37    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:38    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:39    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:40    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:41    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:42    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:43    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:44    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:45    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:46    all    0.50    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   99.50
06:27:47    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:48    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:49    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:50    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:51    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:52    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:53    all    1.01    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   98.99
06:27:54    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:55    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:56    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:57    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:58    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:27:59    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:00    all    0.50    0.00    0.50    0.00    0.00    0.00    0.00    0.00    0.00   99.00
06:28:01    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:02    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:03    all    0.50    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   99.50
06:28:04    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:05    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:06    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:07    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:08    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:09    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:10    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:11    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:12    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:13    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
06:28:14    all    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00  100.00
^Z
(3)+ Stopped      mpstat 1
```

Figure 14: Output for the following commands-

- \$mpstat 1

7. Sysbench CPU commands (native system)

[Run 3 times; results attached for 1 iteration]

```
kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

kanishkb_sait_cse@project1:~$ sysbench --test=cpu --cpu-max-prime=30000 run
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
sysbench 1.0.11 (using system LuaJIT 2.1.0-beta3)

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

Prime numbers limit: 30000
Initializing worker threads...

Threads started!

CPU speed:
events per second: 211.58

General statistics:
total time: 10.0036s
total number of events: 2117

Latency (ms):
min: 4.68
avg: 4.72
max: 5.02
95th percentile: 4.82
sum: 10000.71

Threads fairness:
events (avg/stddev): 2117.0000/0.00
execution time (avg/stddev): 10.0007/0.00

kanishkb_sait_cse@project1:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            1.9G   0 1.9G   0% /dev
tmpfs           393M 1004K 392M   1% /run
/dev/sda1        29G   4.8G   25G  17% /
tmpfs           2.0G   0 2.0G   0% /dev/shm
tmpfs           5.0M   0 5.0M   0% /run/lock
tmpfs           2.0G   0 2.0G   0% /sys/fs/cgroup
/dev/loop0      254M 254M   0 100% /snap/google-cloud-sdk/225
/dev/loop1       56M   56M   0 100% /snap/core18/2284
/dev/sda15      106M  4.4M  100M   5% /boot/efi
```

Figure 15: Output for the following commands-

- \$ sysbench --test=cpu --cpu-max-prime=30000 run
- \$df -h


```

kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhwl-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...
kanishkb_sait_cse@project1:~$ iostat ALL
Linux 5.4.0-1064-gcp (project1) 03/01/22 _x86_64_ (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.44    0.15    0.51    0.65    0.01   97.25

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop0               0.01         0.10         0.00       1087         0
loop1               0.00         0.03         0.00        359         0
loop2               0.12         0.14         0.00       1592         0
loop3               0.94         0.97         0.00      10914         0
loop4               0.01         0.10         0.00       1100         0
loop5               0.00         0.00         0.00         4         0
loop6               0.00         0.00         0.00         0         0
loop7               0.00         0.00         0.00         0         0
sda                 71.70        170.62        841.73     1928108     9512154

kanishkb_sait_cse@project1:~$ iostat -c 10
Linux 5.4.0-1064-gcp (project1) 03/01/22 _x86_64_ (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           1.44    0.15    0.51    0.65    0.01   97.26

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.00    0.00    0.05    0.00    0.00   99.95

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.05    0.00    0.05    0.00    0.00   99.90

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.05    0.00    0.00    0.05    0.05   99.85

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.05    0.00    0.00    0.00    0.00   99.95

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.00    0.00    0.10    0.00    0.00   99.90

```

Figure 16: Output for the following commands-

- \$ iostat ALL
- \$ iostat -c 10

Major Insights

- Total time (average) for the CPU operation under Docker is 47.83 seconds.
- Total time (average) for the CPU operation under native system is 10.578 seconds.
- Hence, it concludes that the performance tools in the native system is running faster than the Docker system for the mandatory condition that the number of runs=30000 remains constant.

8. Sysbench fileio commands (under docker system)

[Run 3 times; results attached for 1 iteration]

```
root@8c55094dd9cf: / - Google Chrome
ssh.cloud.google.com/projects/cloudhwl1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

$ sudo docker pull csminpp/ubuntu-sysbench
Using default tag: latest
latest: Pulling from csminpp/ubuntu-sysbench
Image docker.io/csminpp/ubuntu-sysbench:latest uses outdated schema manifest format. Please upgrade to a schema2 image for better future compatibility. More information at https://docs.docker.com/registry/spec/deprecated-schema-v1/
d89e1bee20d9: Already exists
9e0bc8a71bde: Already exists
27aa681c9ce5: Already exists
a3ed95caeb02: Already exists
55734f896640: Already exists
Digest: sha256:90fd06985472ecc3aa99b665618c23f074deb326fcc87a5fb59d2be1f9d97435
Status: Image is up to date for csminpp/ubuntu-sysbench:latest
docker.io/csminpp/ubuntu-sysbench:latest
root@8c55094dd9cf:~# $ sudo docker run -it --runtime=runc csminpp/ubuntu-sysbench /bin/bash
root@8c55094dd9cf:/# sysbench --test=fileio --file-total-size=2G prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 16384Kb each, 2048Mb total
Creating files for the test...
root@8c55094dd9cf:/# ls
bin          sbin         test_file.106 test_file.118 test_file.15  test_file.27  test_file.39  test_file.50  test_file.62  test_file.74  test_file.86  test_file.98
boot         svb          test_file.107 test_file.119 test_file.16  test_file.28  test_file.40  test_file.51  test_file.63  test_file.75  test_file.87  test_file.99
dev          sys          test_file.108 test_file.12  test_file.17  test_file.29  test_file.41  test_file.52  test_file.64  test_file.76  test_file.88  test_file.90
etc          sysbench    test_file.109 test_file.120 test_file.18  test_file.3   test_file.42  test_file.53  test_file.65  test_file.77  test_file.89  test_file.91
home        test_file.0  test_file.11  test_file.121 test_file.19  test_file.30  test_file.43  test_file.54  test_file.66  test_file.78  test_file.90  test_file.92
lib         test_file.1  test_file.110 test_file.122 test_file.20  test_file.31  test_file.44  test_file.55  test_file.67  test_file.79  test_file.91  test_file.93
lib64       test_file.10 test_file.111 test_file.123 test_file.21  test_file.32  test_file.45  test_file.56  test_file.68  test_file.80  test_file.92  test_file.94
media       test_file.100 test_file.112 test_file.124 test_file.22  test_file.33  test_file.46  test_file.57  test_file.69  test_file.81  test_file.93  test_file.95
mnt         test_file.101 test_file.113 test_file.125 test_file.23  test_file.34  test_file.47  test_file.58  test_file.70  test_file.82  test_file.94  test_file.96
opt         test_file.102 test_file.114 test_file.126 test_file.24  test_file.35  test_file.48  test_file.59  test_file.71  test_file.83  test_file.95  test_file.97
proc        test_file.103 test_file.115 test_file.127 test_file.25  test_file.36  test_file.49  test_file.60  test_file.72  test_file.84  test_file.96  test_file.99
run         test_file.104 test_file.116 test_file.128 test_file.26  test_file.37  test_file.50  test_file.61  test_file.73  test_file.85  test_file.97  test_file.99
root@8c55094dd9cf:/#
```

Figure 17: Output for the following command-

- `$sudo docker pull csminpp/ubuntu-sysbench`
- `$sudo docker run -it --runtime=runc csminpp/ubuntu-sysbench /bin/bash`
- `$sysbench --test=fileio --file-total-size=2G prepare`

```
root@8c55094dd9cf: / - Google Chrome
ssh.cloud.google.com/projects/cloudhwl1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

Commands: prepare run cleanup help version

See 'sysbench --test=<name> help' for a list of options for each test.
root@8c55094dd9cf:/# sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=45 --max-requests=0 run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 1
Extra file open flags: 0
128 files, 16Mb each
2GB total file size
Block size 16Kb
Number of random requests for random IO: 0
Read/Write ratio for combined random IO test: 1.50
Periodic fsync enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Time limit exceeded, exiting...
Done.

Operations performed: 77940 Read, 51960 Write, 166201 Other = 296101 Total
Read 1.1893Gb Written 811.88Mb Total transferred 1.9821Gb (45.104Mb/sec)
2886.63 Requests/sec executed

Test execution summary:
total time: 45.0005s
total number of events: 129900
total time taken by event execution: 4.8145
per-request statistics:
min: 0.00ms
avg: 0.04ms
max: 5.54ms
approx. 95 percentile: 0.22ms

Threads fairness:
events (avg/stddev): 129900.0000/0.00
execution time (avg/stddev): 4.8145/0.00
root@8c55094dd9cf:/#
```

Figure 18: Output for the following command-

`$ sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=45 --max-requests=0 run`

```
root@8c55094dd9cf: / - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

root@8c55094dd9cf:~# sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
root@8c55094dd9cf:~# ls
bin boot dev etc home lib lib64 media mnt opt proc root run sbin srv sys sysbench usr var
root@8c55094dd9cf:~# df -h
Filesystem      Size  Used Avail Use% Mounted on
overlay          29G   4.8G   25G   17% /
tmpfs            64M    0   64M    0% /dev
tmpfs            2.0G    0   2.0G    0% /sys/fs/cgroup
shm              64M    0   64M    0% /dev/shm
/dev/sda1        29G   4.8G   25G   17% /etc/hosts
tmpfs            2.0G    0   2.0G    0% /proc/acpi
tmpfs            2.0G    0   2.0G    0% /proc/scsi
tmpfs            2.0G    0   2.0G    0% /sys/firmware
root@8c55094dd9cf:~#
```

Figure 19: Output for the following command-

- `$ sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw cleanup`

9. Sysbench fileio commands (file system)

[Run 3 times; results attached for 1 iteration]

```
kanishk_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhw1-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

System information as of Wed Mar  2 17:36:52 UTC 2022

System load:  0.0          Processes:      143
Usage of /:   22.9% of 28.9GB  Users logged in:  0
Memory usage: 11%          IP address for ens4: 10.128.0.4
Swap usage:   0%           IP address for docker0: 172.17.0.1

* Super-optimized for small spaces - read how we shrink the memory
  footprint of MicroK8s to make it the smallest full K8s around.
  https://ubuntu.com/blog/microk8s-memory-optimisation

4 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

New release '20.04.4 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

*** System restart required ***
Last login: Wed Mar  2 16:12:23 2022 from 35.235.245.128
kanishk_sait_cse@project1:~$ sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=30 --max-requests=0 run
WARNING: the --test option is deprecated. You can pass a script name or path on the command line without any options.
WARNING: --max-time is deprecated, use --time instead
sysbench 1.0.11 (using system LuaJIT 2.1.0-beta3)

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

Extra file open flags: 0
128 files, 16MiB each
2GiB total file size
Block size 16KiB
Number of IO requests: 0
Read/Write ratio for combined random IO test: 1.50
Periodic fsync enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
FATAL: Cannot open file 'test file.0' errno = 2 (No such file or directory)
WARNING: Did you forget to run the prepare step?
kanishk_sait_cse@project1:~$
```

Figure 20: Output for the following command-

- `$ sysbench --test=fileio --file-total-size=2G --file-test-mode=rndrw --max-time=30 --max-requests=0 run`

```

kanishkb_sait_cse@project1: ~ - Google Chrome
ssh.cloud.google.com/projects/cloudhwl-341115/zones/us-central1-a/instances/project1?authuser=0&hl=en_GB&projectNumber=708542951826&useAdminProxy=true&troubleshoot4005Enabled=true&trouble...

2GiB total file size
Block size 16KiB
Number of IO requests: 0
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
FATAL: Cannot open file 'test_file.0' errno = 2 (No such file or directory)
WARNING: Did you forget to run the prepare step?
kanishkb_sait_cse@project1:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            1.9G   0 1.9G   0% /dev
tmpfs           393M  1.1M 392M   1% /run
/dev/sda1       29G   6.7G  23G  23% /
tmpfs           2.0G   0 2.0G   0% /dev/shm
tmpfs           5.0M   0 5.0M   0% /run/lock
tmpfs           2.0G   0 2.0G   0% /sys/fs/cgroup
/dev/loop0     256M  256M   0 100% /snap/google-cloud-sdk/228
/dev/loop1     255M  255M   0 100% /snap/google-cloud-sdk/227
/dev/loop2      44M   44M   0 100% /snap/snapd/14978
/dev/loop3      56M   56M   0 100% /snap/core18/2284
/dev/sda15     105M   4.4M 100M   5% /boot/efi
tmpfs          393M  20K 393M   1% /run/user/1001
kanishkb_sait_cse@project1:~$ iostat ALL
-bash: syntax error near unexpected token `;'
kanishkb_sait_cse@project1:~$ iostat ALL
Linux 5.4.0-1065-gcp (project1)      03/02/22      _x86_64_      (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
            1.35    0.06    0.68    0.41    0.01   97.49

Device            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop0              0.11         0.24         0.00        1808         0
loop1              0.09         0.23         0.00        1710         0
loop4              0.17         0.21         0.00        1592         0
loop5              0.03         0.07         0.00         526         0
loop6              0.00         0.00         0.00          1         0
loop7              0.00         0.00         0.00          0         0
sda               22.81       121.08       572.62     916486    4334226
kanishkb_sait_cse@project1:~$

```

Figure 21: Output for the following command-

- \$ iostat ALL

Major insights

- The average fileio parameter total time under Docker system for reading files is 47.63 seconds.
- The average fileio parameter total time in native system for reading files is 13.58 seconds.
- Hence the results shows that native system works faster than Docker system.

Reason for late execution of QEMU VM: The QEMU VM emulates all devices due to which it is needed to run a VM guest. The OS executes a system call and it does not connect with the hardware. The system call is going to the hypervisor and the host OS before the call gets executed. Thus, it increases the delay time.

Total Time to install QEMU VM: ~4 Hours (with VNCserver)

Part-II: miniDocker.py

```
*****
*                               *
*      Mini Docker              *
*                               *
*****
20658
root@administrator:/# ls
bin boot dev etc home lib lib64 media mnt opt proc root run sbin srv sys tasks tmp usr var
root@administrator:/# cd home
root@administrator:/home# ls
loop mem
root@administrator:/home# ps -ef
UID        PID  PPID  C  STIME TTY          TIME CMD
root         1      0  0  03:26 ?        00:00:00 /bin/bash
root        18      1  0  03:27 ?        00:00:00 ps -ef
root@administrator:/home# top

top - 03:27:44 up 10:21,  0 users,  load average: 0.00, 0.00, 0.00
Tasks:  2 total,   1 running,  1 sleeping,   0 stopped,   0 zombie
%Cpu(s):  0.7 us,   0.2 sy,   0.0 ni, 98.9 id,   0.2 wa,   0.0 hi,   0.0 si,   0.0 st
KiB Mem:  4022756 total, 1174764 used, 2847992 free,  56576 buffers
KiB Swap:   0 total,    0 used,    0 free. 816304 cached Mem

  PID USER      PR  NI   VIRT   RES   SHR  S  %CPU  %MEM     TIME+ COMMAND
    1 root        20   0 19904   3732  3212  S   0.0   0.1   0:00.00 bash
   19 root        20   0 21572   2604  2248  R   0.0   0.1   0:00.00 top
```

Figure 23: Executing miniDocker.py

```
root@administrator:/home# la
loop mem
root@administrator:/home# ./loop &
[1] 22
root@administrator:/home# ./loop &
[2] 23
root@administrator:/home# ./mem &
[3] 24
root@administrator:/home# ./mem &
[4] 25
[3]  Killed                  ./mem
root@administrator:/home#
```

Figure 24: Test cpuset Cgroup.