

# Assignment 1 - Report

## Lightweight vs. Heavyweight Virtualization Techniques

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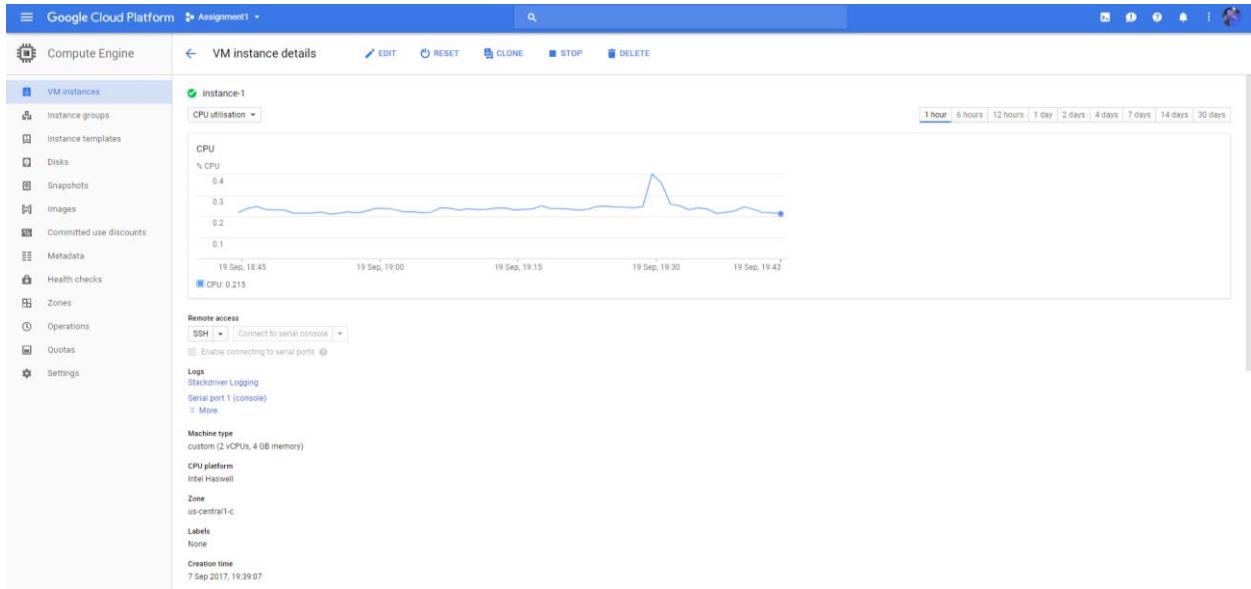
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# 1. Detailed configurations of your experimental setup



Hard Disk  
20GB

Machine type  
custom (2 vCPUs, 4 GB memory)

CPU platform  
Intel Haswell

Zone  
us-central1-c

## 2. Main steps to enable a Docker container

Install gcloud cmd tool  
gcloud compute ssh instance-1

After entering to ssh instance-1  
Update the apt package index  
sudo apt-get update

Install packages to allow apt to use a repository over HTTPS:  
sudo apt-get install \ apt-transport-https \ ca-certificates \ curl \ software-properties-common

Add Docker's official GPG key:  
curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -

Verify that you now have the key with the fingerprint  
sudo apt-key fingerprint 0EBFCD88

Use the following command to set up the **stable** repository.  
**amd64:**

```
$ sudo add-apt-repository \
"deb [arch=amd64] https://download.docker.com/linux/ubuntu \
$(lsb_release -cs) \
stable"
```

**armhf:**

```
$ sudo add-apt-repository \
"deb [arch=armhf] https://download.docker.com/linux/ubuntu \
$(lsb_release -cs) \
stable"
```

**s390x:**

```
$ sudo add-apt-repository \
"deb [arch=s390x] https://download.docker.com/linux/ubuntu \
$(lsb_release -cs) \
stable"
```

## INSTALL DOCKER CE

Update the apt package index.

```
sudo apt-get update
```

Install the latest version of Docker CE

```
sudo apt-get install docker-ce
```

```
sudo docker run hello-world
```

->Hello from Docker!

This message shows that installation appears to be working correctly.

Whenever we need to clear cache we need to exit docker first. For that we have command called

```
$ exit
```

And then we can access root rights with

```
$ sudo -i
```

And before we enter to docker we first need to exit from root

```
$ exit
```

3. Main steps to enable a QEMU VM. In addition, please present the detailed QEMU commands, and VM configurations.

1. Installing qemu (under Ubuntu) simply by:

```
$sudo apt-get install qemu
```

2. Downloading the Ubuntu iso image to install your QEMU VM:

```
$wget http://mirror.pnl.gov/releases/16.04/ubuntu-16.04.3-server-amd64.iso
```

3. You need to create an image before installing your QEMU VM of size 10 GB

```
$sudo qemu-img create ubuntu.img 10G
```

```
qemu-img create myimage.img mysize
```

where *myimage.img* is the disk image filename and *mysize* is its size in kilobytes.

You can add an M suffix to give the size in megabytes and a G suffix for gigabytes.

For graphical user interface (GUI) using VNC client.

Steps to install VNC

Installing a Virtual Desktop using VNC

```
$ sudo apt-get install vnc4server
```

```
$ vncserver
```

Prompts for password to set.

I set password as vncserve

To kill session

```
$ vncserver -kill :1
```

Edit xstartup as stated in the assignment pdf

```
$ vim .vnc/xstartup
```

Press I to insert mode

Replacing whole content with

```
#!/bin/sh
def
export XKL_XMODMAP_DISABLE=1
unset SESSION_MANAGER
unset DBUS_SESSION_BUS_ADDRESS
metacity &
gnome-settings-daemon &
gnome-panel &
nautilus &
gnome-terminal
```

Press Esc and save by  
:wq

Creating Firewall rules for vnc-server :

The screenshot shows the Google Cloud Platform interface for managing VPC networks. On the left, a sidebar lists options like VPC networks, External IP addresses, Firewall rules (which is selected and highlighted in blue), Routes, VPC network peering, and Shared VPC. The main panel displays the details of a specific firewall rule named 'vnc-server'. The rule is associated with the 'default' network and has a priority of 1000. It is set to allow Ingress traffic from any source (IP ranges 0.0.0.0/0) on ports tcp:5000-10000. The action on match is 'Allow'. There is also a note about equivalent REST API.

Downloading VNC Client  
And entering VNC Server address as  
External id : Port  
104.154.179.128:5901

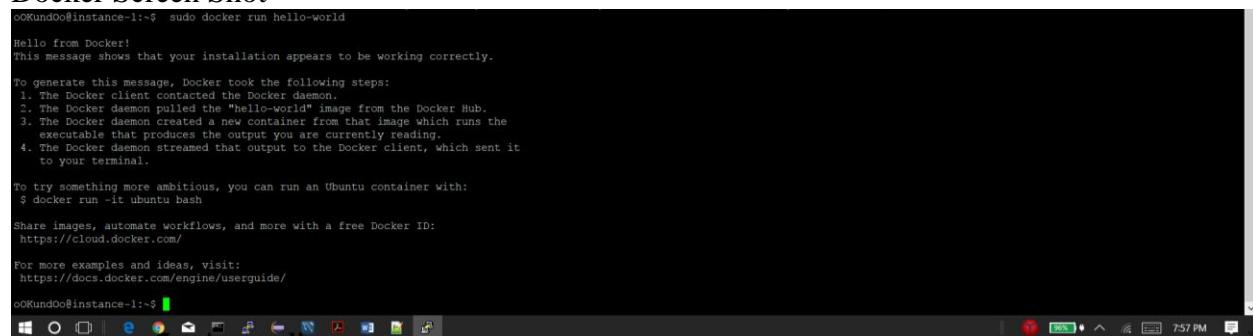
Install QEMU by following command

It treats ./ubuntu-16.04.3-server-amd64.iso as CDROM  
QEMU image as Hard Disk

```
$sudo qemu-system-x86_64 -hda ubuntu.img -boot d -cdrom ./ubuntu-16.04.3-server-amd64.iso -m 1536
```

## 4. Proofs (screen snapshots of your Docker and QEMU running environments).

### Docker Screen Shot



```
oOKundO@instance-1:~$ sudo docker run hello-world
Hello from Docker!
This message shows that your installation appears to be working correctly.

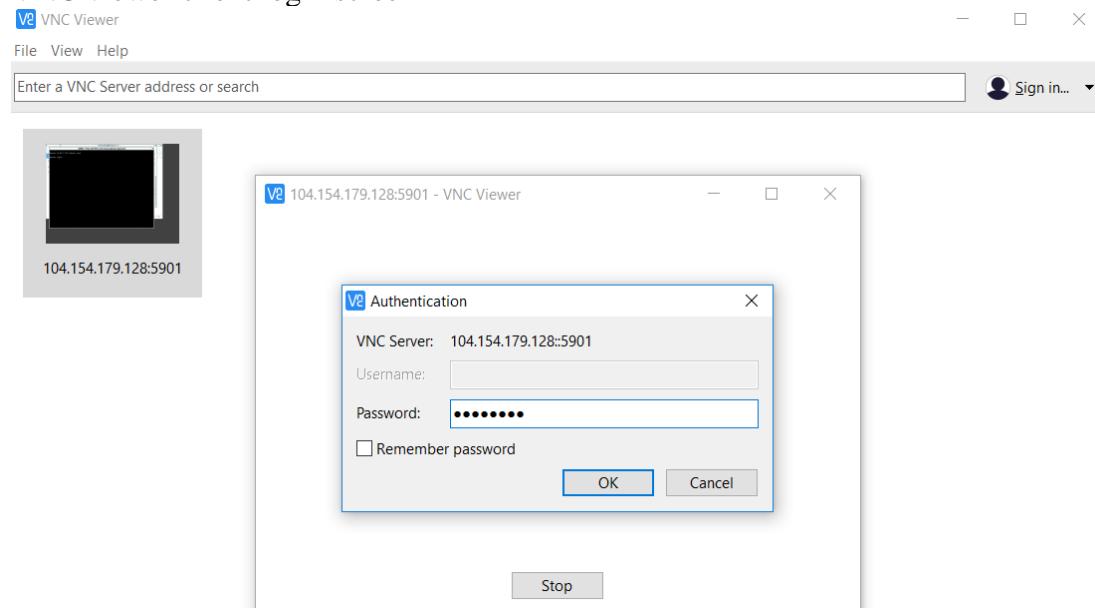
To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
 3. The Docker daemon created a new container from that image which runs the
 executable that produces the output you 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

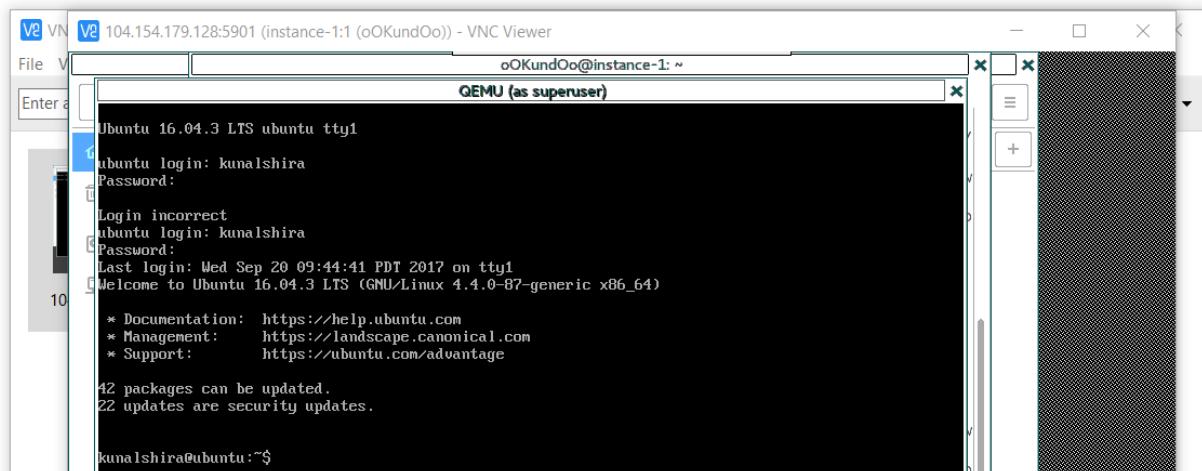
Share images, automate workflows, and more with a free Docker ID:
 https://cloud.docker.com/

For more examples and ideas, visit:
 https://docs.docker.com/engine/userguide/
```

### VNC viewer client login screen



### QEMU Screen Shot



5. Present how you conduct your measurements in three different scenarios (the native, Docker, and QEMU).

## Native System:

**CPU Mode :-**

```
pOKundoo@instance-1:~  
Welcome to Ubuntu 16.04.3 LTS (GNU/Linux 4.10.0-33-generic x86_64)  
  
 * Documentation: https://help.ubuntu.com  
 * Management: https://landscape.canonical.com  
 * Support: https://ubuntu.com/advantage  
  
Get cloud support with Ubuntu Advantage Cloud Guest:  
 http://www.ubuntu.com/business/services/cloud  
  
22 packages can be updated.  
0 updates are security updates.  
  
*** System restart required ***  
Last login: Wed Sep 20 15:23:49 2017 from 67.241.247.66  
cOKundoo@instance-1:~$ sudo apt-get update  
Hit:1 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial InRelease  
Hit:2 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial-updates InRelease  
Hit:3 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial-backports InRelease  
Hit:4 http://security.ubuntu.com/ubuntu xenial-security InRelease  
Hit:5 http://archive.canonical.com/ubuntu xenial InRelease  
Hit:6 https://download.docker.com/linux/ubuntu xenial InRelease  
Reading package lists... Done  
W: Target Packages (stable/binary-all/Packages) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/i18n/Translation-en_US) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/binary-all/Translations) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Packages (stable/binary-all/Packages) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:62  
W: Target Translations (stable/i18n/Translation-en_US) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:62  
W: Target Packages (stable/binary-all/Packages) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:62  
W: Target Translations (stable/i18n/Translation-en_US) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:62  
W: Target Translations (stable/i18n/Translation-en) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/i18n/Translation-en) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/i18n/Translation-en) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/i18n/Translation-en) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/i18n/Translation-en) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
W: Target Translations (stable/i18n/Translation-en) is configured multiple times in /etc/apt/sources.list:58 and /etc/apt/sources.list:60  
cOKundoo@instance-1:~$ sudo apt-get install sysbench  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following packages were automatically installed and are no longer required:  
  linux-headers-4.10.0-32 linux-headers-4.10.0-32-generic linux-image-4.10.0-32-generic  
Use 'sudo apt autoremove' to remove them.  
The following additional packages will be installed:  
  libmysqlclient20 mysql-common  
The following NEW packages will be installed:  
  libmysqld-client20 libmysqlclient20-sysbench  
0 upgraded, 3 newly installed, 0 to remove and 22 not upgraded.  
Need to get 883 kB of archives.  
After this operation, 4,767 kB of additional disk space will be used.  
Do you want to continue? [Y/n] N
```

```
oOKundoo@instance-1: ~
Get:1 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial-updates/main amd64 mysql-common all 5.7.19-0ubuntu0.16.04.1 [15.7 kB]
Get:2 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial-updates/main amd64 libmysqlclient20 amd64 5.7.19-0ubuntu0.16.04.1 [809 kB]
Get:3 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial/universe amd64 sysbench amd64 0.4.12-1.lubuntu1 [57.6 kB]
Fetched 883 kB in 0s (20.8 MB/s)
Selecting previously unselected package mysql-common.
(Reading database ... 188673 files and directories currently installed.)
Preparing to unpack .../mysql-common_5.7.19-0ubuntu0.16.04.1_all.deb ...
Unpacking mysql-common (5.7.19-0ubuntu0.16.04.1) ...
Selecting previously unselected package libmysqlclient20:amd64.
Preparing to unpack .../libmysqlclient20_5.7.19-0ubuntu0.16.04.1_amd64.deb ...
Unpacking libmysqlclient20:amd64 (5.7.19-0ubuntu0.16.04.1) ...
Selecting previously unselected package sysbench.
Preparing to unpack .../sysbench_0.4.12-1.lubuntu1_amd64.deb ...
Unpacking sysbench (0.4.12-1.lubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu9) ...
Processing triggers for man-db (0.7.5-1) ...
Setting up mysql-common (5.7.19-0ubuntu0.16.04.1) ...
update-alternatives: using /etc/mysql/my.cnf.fallback to provide /etc/mysql/my.cnf (my.cnf) in auto mode
Setting up libmysqlclient20:amd64 (5.7.19-0ubuntu0.16.04.1) ...
Setting up sysbench (0.4.12-1.lubuntu1) ...
Processing triggers for libc-bin (2.23-0ubuntu9) ...
oOKundoo@instance-1:~$ sudo sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
 total time: 37.1932s
 total number of events: 10000
 total time taken by event execution: 37.1895
 per-request statistics:
    min:                      3.65ms
    avg:                      3.72ms
    max:                      6.42ms
    approx. 95 percentile:     3.86ms

Threads fairness:
  events (avg/stddev):      10000.0000/0.00
  execution time (avg/stddev): 37.1895/0.00

oOKundoo@instance-1:~$
```

```
pOKundOo@instance-1:~  
pOKundOo@instance-1:~$ sudo sysbench --test=cpu --cpu-max-prime=25000 run  
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: 25000  
  
Test execution summary:  
total time: 37.25109s  
total number of events: 10000  
total time taken by event execution: 37.2470  
per-request statistics:  
min: 3.65ms  
avg: 3.72ms  
max: 6.19ms  
approx. 95 percentile: 3.88ms  
  
Threads fairness:  
events (avg/stddev): 10000.0000/0.00  
execution time (avg/stddev): 37.2470/0.00  
pOKundOo@instance-1:~$
```

```
pOKundOo@instance-1:~  
pOKundOo@instance-1:~$ sudo sysbench --test=cpu --cpu-max-prime=25000 run  
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: 25000  
  
Test execution summary:  
total time: 37.4119s  
total number of events: 10000  
total time taken by event execution: 37.4074  
per-request statistics:  
min: 3.65ms  
avg: 3.74ms  
max: 8.20ms  
approx. 95 percentile: 3.97ms  
  
Threads fairness:  
events (avg/stddev): 10000.0000/0.00  
execution time (avg/stddev): 37.4074/0.00  
pOKundOo@instance-1:~$
```

## Fileio Mode : -

Creating and then cleaning up 128 files of size 5 GB with 2 threads  
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare  
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run  
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup

After execution of each command clearing cache through root mode  
To reach to root mode  
\$ sudo -i

Clearing cache  
echo3 > =proc=sys=vm=dropcaches

To exit from that root mode  
Exit

Repeating above process for fileio 3 times

```
oOKundOo@instance-1:~  
oOKundOo@instance-1:~$ sudo -i  
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches  
root@instance-1:~# exit  
logout  
oOKundOo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare  
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup  
sysbench 0.4.12: multi-threaded system evaluation benchmark  
  
128 files, 40960Kb each, 5120Mb total  
Creating files for the test.  
oOKundOo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run  
sysbench 0.4.12: multi-threaded system evaluation benchmark  
  
Running the test with following options:  
Number of threads: 2  
  
Extra file open flags: 0  
128 files, 40Mb each  
5Gb total file size  
Block size 16kB  
Number of random requests for random IO: 10000  
Read/Write ratio for combined random IO test: 1.50  
Periodic FSYNC enabled, calling sync() each 100 requests.  
Calling sync() at the end of test, Enabled.  
Using synchronous I/O mode  
Doing random r/w test  
Threads started!  
Done.  
  
Operations performed: 6002 Read, 4000 Write, 12800 Other = 22802 Total  
Read 93.781Mb Written 62.5MB Total transferred 156.28Mb (3.934Mb/sec)  
251.77 Requests/sec executed  
  
Test execution summary:  
total time: 39.7261s  
total number of events: 10002  
total time taken by event execution: 76.4617  
per-request statistics:  
min: 0.00ms  
avg: 7.64ms  
max: 153.16ms  
approx. 95 percentile: 31.61ms  
  
Threads fairness:  
events (avg/stddev): 5001.0000/85.00  
execution time (avg/stddev): 38.2308/0.13  
  
oOKundOo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup  
sysbench 0.4.12: multi-threaded system evaluation benchmark  
  
Removing test files...  
oOKundOo@instance-1:~$
```

```
oOKundOo@instance-1:~  
oOKundOo@instance-1:~$ sudo -i  
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches  
root@instance-1:~# exit  
logout  
oOKundOo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare  
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run  
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup  
sysbench 0.4.12: multi-threaded system evaluation benchmark  
  
128 files, 40960Kb each, 5120Mb total  
Creating files for the test.  
oOKundOo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run  
sysbench 0.4.12: multi-threaded system evaluation benchmark  
  
Running the test with following options:  
Number of threads: 2  
  
Extra file open flags: 0  
128 files, 40Mb each  
5Gb total file size  
Block size 16kB  
Number of random requests for random IO: 10000  
Read/Write ratio for combined random IO test: 1.50  
Periodic FSYNC enabled, calling sync() each 100 requests.  
Calling sync() at the end of test, Enabled.  
Using synchronous I/O mode  
Doing random r/w test  
Threads started!  
Done.  
  
Operations performed: 6005 Read, 4002 Write, 12800 Other = 22807 Total  
Read 93.828Mb Written 62.531MB Total transferred 156.36Mb (3.946Mb/sec)  
252.58 Requests/sec executed  
  
Test execution summary:  
total time: 39.6192s  
total number of events: 10007  
total time taken by event execution: 76.2562  
per-request statistics:  
min: 0.00ms  
avg: 7.62ms  
max: 183.00ms  
approx. 95 percentile: 32.04ms  
  
Threads fairness:  
events (avg/stddev): 5003.5000/90.50  
execution time (avg/stddev): 38.1281/0.03  
  
oOKundOo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup  
sysbench 0.4.12: multi-threaded system evaluation benchmark  
  
Removing test files...
```

```

oOkundoo@instance-1: ~
oOkundoo@instance-1:~$ sudo -i
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches
root@instance-1:~# exit
logout
oOkundoo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960Kb each, 5120Mb total
Creating files for the test...
oOkundoo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 40Mb each
5Gb total file size
Block size: 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling sync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6002 Read, 4000 Write, 12800 Other = 22802 Total
Read 93.781Mb Written 62.595 Mb Total transferred 156.28MB (4.0081MB/sec)
256.52 Requests/sec executed

Test execution summary:
total time: 38.9909s
total number of events: 10002
total time taken by event execution: 75.0321
per-request statistics:
    min: 0.00ms
    avg: 7.50ms
    max: 153.89ms
    approx. 95 percentile: 31.16ms

Threads fairness:
events (avg/stddev): 5001.0000/44.00
execution time (avg/stddev): 37.5160/0.09

oOkundoo@instance-1:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...

```

Please refer commands used for testing in detail in the above screen shots (results of table are in seconds).

Native System:

Mode	Test1	Test2	Test3	Average
CPU	37.19	37.25	37.41	37.28
FILEIO	39.72	39.61	38.99	39.44

Docker :

The pull command fetches the csmminpp/ubuntu-sysbench image from the Docker registry and saves it in our system to check benchmark

```
$ docker pull csmminpp/ubuntu-sysbench
```

Making sure it works properly

```
sudo docker run csmminpp/ubuntu-sysbench echo "hello from ubuntu"
```

Running bin/ssh of sysbench

```
sudo docker run -it csmminpp/ubuntu-sysbench /bin/sh
```

## CPU Mode :-

Running max-prime till 25000 – 3 times  
sysbench --test=cpu --cpu-max-prime=25000 run

```
# sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
total time: 37.6783s
total number of events: 10000
total time taken by event execution: 37.6732
per-request statistics:
    min: 3.64ms
    avg: 3.77ms
    max: 8.77ms
    approx. 95 percentile: 3.97ms
```

```
Threads fairness:
events (avg/stddev): 10000.0000/0.00
execution time (avg/stddev): 37.6732/0.00

# sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
total time: 37.8391s
total number of events: 10000
total time taken by event execution: 37.8338
per-request statistics:
    min: 3.64ms
    avg: 3.78ms
    max: 7.12ms
    approx. 95 percentile: 4.01ms

Threads fairness:
events (avg/stddev): 10000.0000/0.00
execution time (avg/stddev): 37.8338/0.00
```

```
# sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
total time: 38.2785s
total number of events: 10000
total time taken by event execution: 38.2726
per-request statistics:
    min: 3.64ms
    avg: 3.83ms
    max: 6.73ms
    approx. 95 percentile: 4.39ms

Threads fairness:
events (avg/stddev): 10000.0000/0.00
execution time (avg/stddev): 38.2726/0.00
```

## Fileio Mode : -

Creating and then cleaning up 128 files of size 5 GB with 2 threads

```
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
```

After execution of each command clearing cache through root mode

To reach to root mode

```
$ sudo -i
```

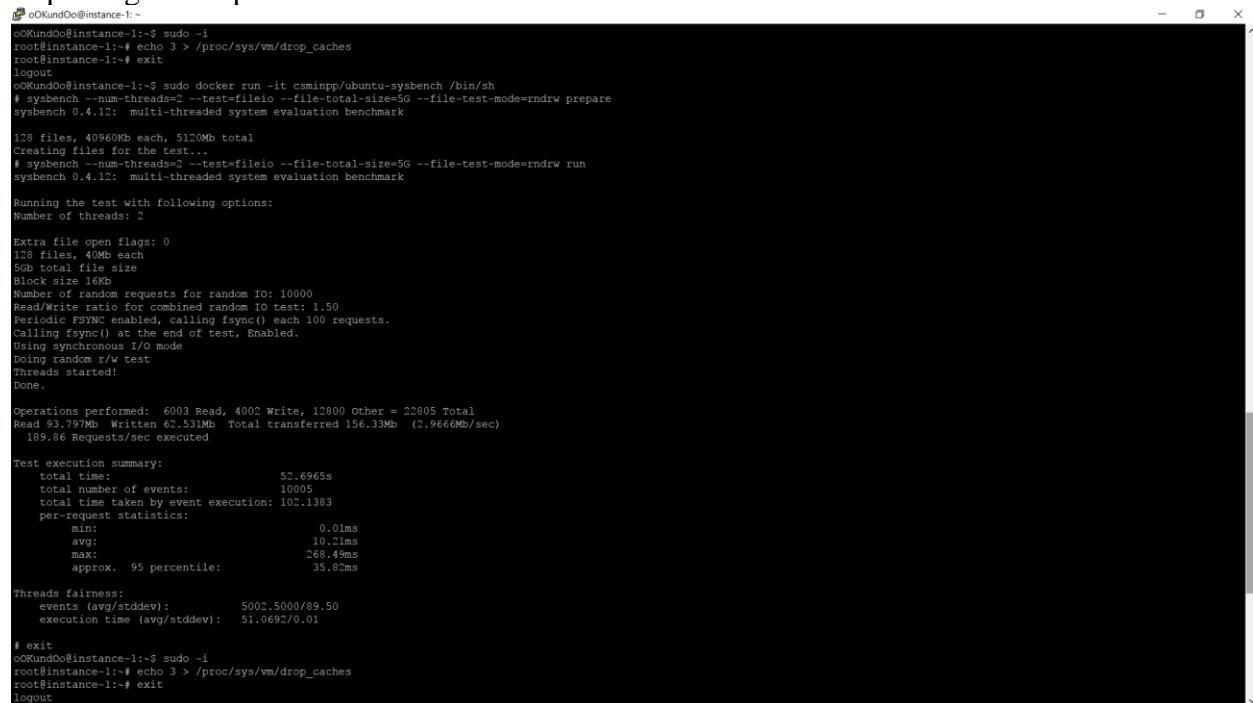
Clearing cache

```
echo3 > /proc/sys/vm/dropcaches
```

To exit from that root mode

```
Exit
```

Repeating above process for fileio 3 times



```
oOkundo@instance-1:~$ sudo -i
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches
root@instance-1:~# exit
logout
oOkundo@instance-1:~$ sudo docker run -it csmnpp/ubuntu-sysbench /bin/sh
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960Kb each, 5120Mb total
Creating files for the test...
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 5120Mb each
5000000 file size
block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6003 Read, 4002 Write, 12800 Other = 22805 Total
Read 93.797Mb Written 62.531Mb Total transferred 156.33Mb (2.9660Mb/sec)
 189.86 Requests/sec executed

Test execution summary:
  total time: 52.6965s
  total number of events: 10005
  total time taken by event execution: 102.1383
  per-request statistics:
    min: 0.01ms
    avg: 10.21ms
    max: 268.49ms
    approx. 95 percentile: 35.82ms

Threads fairness:
  events (avg/stddev): 5002.5000/89.50
  execution time (avg/stddev): 51.0692/0.01

# exit
oOkundo@instance-1:~$ sudo -i
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches
root@instance-1:~# exit
logout
```

```

oGundo@instance-1:~$ sudo docker run -it csmingpp/ubuntu-sysbench /bin/sh
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960KB each, 5120MB total
Creating files for the test...
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 4096KB each
5GB total file size
Block size 16KB
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling sync() each 100 requests.
Calling sync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6003 Read, 4002 Write, 12800 Other = 22805 Total
Read 93.797MB Written 62.531MB Total transferred 156.33MB (2.9666MB/sec)
189.86 Requests/sec executed

Test execution summary:
total time: 50.1285s
total number of events: 10005
total time taken by event execution: 102.1383
per-request statistics:
    min: 0.01ms
    avg: 10.21ms
    max: 260.49ms
    approx. 95 percentile: 35.82ms

Threads fairness:
events (avg/stddev): 5002.5000/89.50
execution time (avg/stddev): 50.0692/0.01

# exit

```

```

oGundo@instance-1:~$ sudo docker run -it csmingpp/ubuntu-sysbench /bin/sh
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960KB each, 5120MB total
Creating files for the test...
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 4096KB each
5GB total file size
Block size 16KB
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling sync() each 100 requests.
Calling sync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6005 Read, 4002 Write, 12800 Other = 22807 Total
Read 93.828MB Written 62.531MB Total transferred 156.36MB (3.8661MB/sec)
247.43 Requests/sec executed

Test execution summary:
total time: 50.4434s
total number of events: 10007
total time taken by event execution: 78.0012
per-request statistics:
    min: 0.00ms
    avg: 7.79ms
    max: 211.96ms
    approx. 95 percentile: 30.16ms

Threads fairness:
events (avg/stddev): 5003.5000/102.50
execution time (avg/stddev): 49.0006/0.03

```

Please refer commands used for testing in detail in the above screen shots (results of table are in seconds).

Docker System:

Mode	Test1	Test2	Test3	Average
CPU	37.67	37.83	38.27	37.92
FILEIO	52.69	50.12	50.44	51.08

## QEMU System :

### Setup -

The screenshot shows a VNC session titled "V2 104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer". The terminal window has a title bar "oOKundOo@instance-1: ~" and a header "QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)". The terminal content is as follows:

```
QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)
Password:
Login incorrect
ubuntu login: kunalshira
Password:
Last login: Wed Sep 20 09:44:41 PDT 2017 on tty1
Welcome to Ubuntu 16.04.3 LTS (GNU/Linux 4.4.0-87-generic x86_64)

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

42 packages can be updated.
22 updates are security updates.

kunalshira@ubuntu:~$ sudo apt-get update
[sudo] password for kunalshira:
Hit:1 http://us.archive.ubuntu.com/ubuntu xenial InRelease
Get:2 http://us.archive.ubuntu.com/ubuntu xenial-updates InRelease [102 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu xenial-backports InRelease [102 kB]
Get:4 http://security.ubuntu.com/ubuntu xenial-security InRelease [102 kB]
Get:5 http://us.archive.ubuntu.com/ubuntu xenial-updates/main amd64 Packages [631 kB]
Get:6 http://us.archive.ubuntu.com/ubuntu xenial-updates/main i386 Packages [603 kB]
Get:7 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe amd64 Packages [536 kB]
Get:8 http://us.archive.ubuntu.com/ubuntu xenial-updates/universe i386 Packages [512 kB]
Fetched 2,588 kB in 19s (134 kB/s)

Reading package lists... Done
kunalshira@ubuntu:~$ 
kunalshira@ubuntu:~$ sudo apt-get install sysbench
Reading package lists... Done
Building dependency tree
Reading state information... Done
sysbench is already the newest version (0.4.12-1.1ubuntu1).
0 upgraded, 0 newly installed, 0 to remove and 38 not upgraded.
kunalshira@ubuntu:~$ _
```

## CPU Mode :-

V 10.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer

oOKundOo@instance-1: ~

**QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)**

```
kunalshira@ubuntu:~$ sudo sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
  total time:          91.3149s
  total number of events:    10000
  total time taken by event execution: 91.2707
  per-request statistics:
    min:                  8.73ms
    avg:                  9.13ms
    max:                 24.71ms
    approx. 95 percentile: 9.81ms

Threads fairness:
  events (avg/stddev):   10000.0000/0.00
  execution time (avg/stddev): 91.2707/0.00

kunalshira@ubuntu:~$ _
```

VNC 104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer

oOKundOo@instance-1: ~

QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)

```
kunalshira@ubuntu:~$ sudo sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
    total time:          91.4346s
    total number of events: 10000
    total time taken by event execution: 91.3901
    per-request statistics:
        min:                8.73ms
        avg:                9.14ms
        max:                22.81ms
        approx. 95 percentile: 9.81ms

Threads fairness:
    events (avg/stddev): 10000.0000/0.00
    execution time (avg/stddev): 91.3901/0.00

kunalshira@ubuntu:~$ _
```

VNC 104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer

oOKundOo@instance-1: ~

**QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)**

```
kunalshira@ubuntu:~$ sudo sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
  total time:          90.8589s
  total number of events:    10000
  total time taken by event execution: 90.8183
  per-request statistics:
    min:                8.72ms
    avg:                9.08ms
    max:               19.40ms
    approx. 95 percentile: 9.71ms

Threads fairness:
  events (avg/stddev):   10000.0000/0.00
  execution time (avg/stddev): 90.8183/0.00

kunalshira@ubuntu:~$
```

## FILEIO Mode : -

```
VNC Viewer 104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer
File Edit Enter
oOKundOo@instance-1: ~
QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)
kunalshira@ubuntu:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare;sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark
128 files, 40960Kb each, 5120Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 40Mb each
5Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
```

```
VNC Viewer 104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer
File Edit Enter
oOKundOo@instance-1: ~
QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6001 Read, 4000 Write, 12000 Other = 22001 Total
Read 93.768Mb Written 62.5Mb Total transferred 156.27Mb (1.3725Mb/sec)
87.84 Requests/sec executed

Test execution summary:
total time: 113.8523s
total number of events: 10001
total time taken by event execution: 203.2325
per-request statistics:
    min: 0.03ms
    avg: 20.32ms
    max: 362.11ms
    approx. 95 percentile: 63.91ms

Threads fairness:
events (avg/stddev): 5000.5000/12.50
execution time (avg/stddev): 101.6162/0.15

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
kunalshira@ubuntu:~$ sudo -i
[sudo] password for kunalshira:
root@ubuntu:~# echo 3 > /proc/sys/vm/drop_caches
root@ubuntu:~# exit
logout
kunalshira@ubuntu:~$
```

```
VNC Viewer 104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer
File Edit Enter
oOKundOo@instance-1: ~
QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)
kunalshira@ubuntu:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare;sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark
128 files, 40960Kb each, 5120MB total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 40Mb each
```

```

104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer
oOKundOo@instance-1: ~
GEMU - Press Ctrl-Alt to exit mouse grab (as superuser)

5Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
ReadWrite 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!
Done.

Operations performed: 6003 Read, 4002 Write, 12800 Other = 22805 Total
Read 93.797Mb Written 62.531Mb Total transferred 156.33Mb (1.3263Mb/sec)
84.88 Requests/sec executed

Test execution summary:
total time: 117.8659s
total number of events: 10005
total time taken by event execution: 211.9518
per-request statistics:
    min: 0.03ms
    avg: 21.18ms
    max: 245.04ms
    approx. 95 percentile: 67.00ms

Threads fairness:
events (avg/stddev): 5002.5000/19.50
execution time (avg/stddev): 105.9759/0.06

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
kunalshira@ubuntu:~$ sudo -i
root@ubuntu:~# echo 3 > /proc/sys/vm/drop_caches
root@ubuntu:~# exit
logout
kunalshira@ubuntu:~$ _

```

```

104.154.179.128:5901 (instance-1:1 (oOKundOo)) - VNC Viewer
oOKundOo@instance-1: ~
GEMU - Press Ctrl-Alt to exit mouse grab (as superuser)

kunalshira@ubuntu:~$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare;sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw
sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw cleanup
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960Kb each, 5120Mb total
Creating files for the test...
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:

```

```

oOKundOo@instance-1: ~
GEMU - Press Ctrl-Alt to exit mouse grab (as superuser)

Number of threads: 2
Extra file open flags: 0
128 files, 40Mb each
5Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
ReadWrite 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!
Done.

Operations performed: 6001 Read, 4000 Write, 12800 Other = 22801 Total
Read 93.766Mb Written 62.5Mb Total transferred 156.27Mb (1.4442Mb/sec)
92.43 Requests/sec executed

Test execution summary:
total time: 108.2044s
total number of events: 10001
total time taken by event execution: 193.1209
per-request statistics:
    min: 0.03ms
    avg: 19.31ms
    max: 231.08ms
    approx. 95 percentile: 61.76ms

Threads fairness:
events (avg/stddev): 5000.5000/13.50
execution time (avg/stddev): 96.5604/0.15

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
kunalshira@ubuntu:~$ 

```

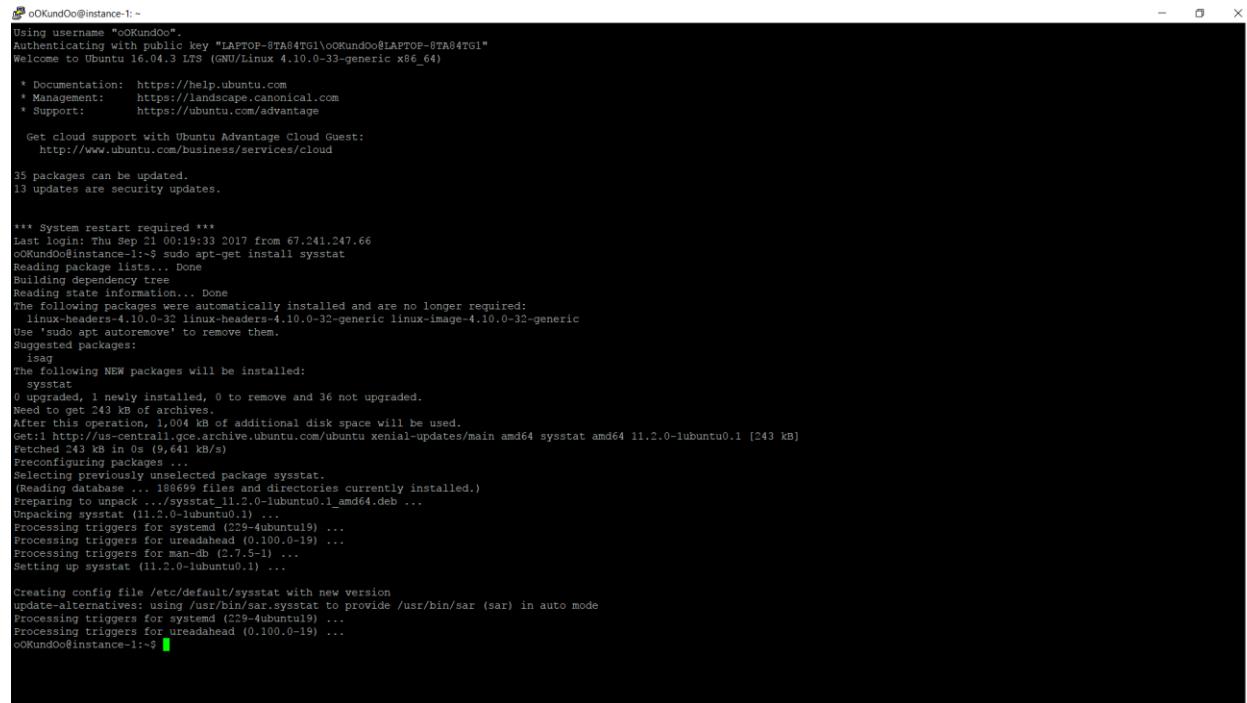
Please refer commands used for testing in detail in the above screen shots (results of table are in seconds).

### QEMU System:

Mode	Test1	Test2	Test3	Average
CPU	91.31	91.43	90.85	91.19
FILEIO	113.85	117.86	108.20	113.30

**6.\_**Present how you use performance tools to collect performance data. For CPU utilization, you should at least divide them into two parts including user-level and kernel-level. For I/O, you should present I/O throughput, latency, and disk utilization

### Installation of iostat on native



```
oOKundo@instance-1:~$ Using username "oOKundo".
Authenticating with public key "LAPTOP-8TA04TGI\oOKundo@LAPTOP-8TA04TGI"
Welcome to Ubuntu 16.04.3 LTS (GNU/Linux 4.10.0-33-generic x86_64)

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

 Get cloud support with Ubuntu Advantage Cloud Guest:
 http://www.ubuntu.com/business/services/cloud

35 packages can be updated,
13 updates are security updates.

*** system restart required ***
Last login: Thu Sep 21 00:19:33 2017 from 67.241.247.66
oOKundo@instance-1:~$ sudo apt-get install sysstat
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
linux-headers-4.10.0-32 linux-headers-4.10.0-32-generic linux-image-4.10.0-32-generic
Use 'sudo apt autoremove' to remove them.
Suggested packages:
lsgag
The following NEW packages will be installed:
sysstat
0 upgraded, 1 newly installed, 0 to remove and 36 not upgraded.
Need to get 243 kB of archives.
After this operation, 1,004 kB of additional disk space will be used.
Get:1 http://us-central1.gce.archive.ubuntu.com/ubuntu xenial-updates/main amd64 sysstat amd64 11.2.0-1ubuntu0.1 [243 kB]
Fetched 243 kB in 0s (9,641 kB/s)
Preconfiguring packages ...
Selecting previously unselected package sysstat.
(Reading database ... 188699 files and directories currently installed.)
Preparing to unpack .../sysstat_11.2.0-1ubuntu0.1_amd64.deb ...
Unpacking sysstat (11.2.0-1ubuntu0.1) ...
Processing triggers for systemd (229-4ubuntu19) ...
Processing triggers for ureadahead (0.100.0-19) ...
Processing triggers for man-db (2.7.5-1) ...
Setting up sysstat (11.2.0-1ubuntu0.1) ...

Creating config file /etc/default/sysstat with new version
update-alternatives: using /usr/bin/sar.sysstat to provide /usr/bin/sar (sar) in auto mode
Processing triggers for systemd (229-4ubuntu19) ...
Processing triggers for ureadahead (0.100.0-19) ...
oOKundo@instance-1:~$
```

Native :

Iostat with 10 iterations every 5 seconds in CPU Mode :-

Iostat with 10 iterations every 6 seconds in fileio Mode :-

```
o0Kundo0@instance-1: ~
o0Kundo0@instance-1: ~ lsstat 6 10
Linux 4.10.0-39-generic (instance-1) 09/21/2017 _w86_64_ (2 CPU)

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          1.46    0.11    0.50    97.92

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      5.42     14.17    570.32   4456104  179334508

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          17.58    0.00    0.99    48.19    0.00   33.31

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     367.33    1394.00   1182.00    8364   6912

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          24.96    0.00    1.51    50.63    0.00   22.88

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     395.33    1370.67   1164.67    8224   7588

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          32.76    0.00    1.84    50.59    0.00   14.82

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     459.17    1394.67   1300.00    8908   9000

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          23.75    0.00    52.14    22.88

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     427.17    1424.00   1380.67    8544   8296

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          22.15    0.00    1.09    56.96    0.00   19.80

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     398.50    1394.67   1270.67    8368   7636

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          21.65    0.00    0.76    56.61    0.00   20.98

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     458.83    1485.33   1498.00    8912   8988

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          24.20    0.00    1.01    51.18    0.00   33.61

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     428.00    1394.00   1380.00    8364   8280

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          22.40    0.00    1.27    57.33    0.00   19.10

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     426.33    1405.33   1380.00    8432   8340

avg-cpu:  user   0.00  sys   0.00  %iowait  0.000  %idle
          15.62    0.00    0.84    25.10    0.00   58.44

Device:     tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     211.33    674.67    694.00    4048   4164

o0Kundo0@instance-1: ~
o0Kundo0@instance-1: ~ sudo -i
root@instance-1: ~ echo 3 > /proc/sys/vm/drop_caches
root@instance-1: ~ exit
logout
o0Kundo0@instance-1: ~ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960Kb each, 5120Mb total
Creating files for the test.
o0Kundo0@instance-1: ~ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 40MB each
56G total file size
Block size: 16KB
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fSync() each 100 requests.
Calling fSync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6003 Read, 4001 Write, 12800 Other = 22804 Total
Read 98.797Mb Written 62.516Mb Total transferred 156.31Mb (3.1426Mb/sec)
2011.3 Requests/sec executed

Test execution summary:
total time:                                49.7394s
total number of events:                      10004
total time taken by event execution:        96.4204
per-request statistics:
min:                                         0.00ms
avg:                                         9.64ms
max:                                         256.70ms
approx. 95 percentile:                      35.10ms

Threads fairness:
events (avg/stddev):                      5002.0000/24.00
execution time (avg/stddev):                48.2102/0.11

o0Kundo0@instance-1: ~
```

Docker :

Iostat with 10 iterations every 7 seconds in CPU Mode :-

The screenshot shows two terminal windows side-by-side. The left window displays the output of the command `iostat -t 10`, showing disk I/O statistics over 10 iterations. The right window shows the output of `sysbench --test=cpu --cpu-max-prime=25000 run`, providing a detailed test execution summary including total time, event count, and percentile statistics.

```
oOKundOo@instance-1:~
avg-cpu: %user %nice %system %iowait %steal %idle
        0.14  0.00  1.01  82.93  0.00  15.92
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     398.29   1375.43   1270.29    9628    8892
avg-cpu: %user %nice %system %iowait %steal %idle
        0.22  0.00  0.00  0.43  0.00  99.35
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     1.29   22.29    1.71    156      12
oOKundOo@instance-1:~$ iostat -t 10
Linux 4.10.0-33-generic (instance-1) 09/21/2017 _x86_64_ (2 CPU)
avg-cpu: %user %nice %system %iowait %steal %idle
        1.45  0.01  0.11  0.53  0.00  97.90
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     5.40   14.87   582.78   4714220  18472650
avg-cpu: %user %nice %system %iowait %steal %idle
        0.90  0.00  0.07  4.49  0.00  92.58
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     25.86   424.00   424.00    0.57    2960      4
avg-cpu: %user %nice %system %iowait %steal %idle
        51.00  0.00  0.07  2.30  0.00  46.63
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     0.29   166.29   0.57    744      4
avg-cpu: %user %nice %system %iowait %steal %idle
        50.67  0.00  0.00  0.36  0.00  49.07
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     0.57   14.59   0.00    100      0
avg-cpu: %user %nice %system %iowait %steal %idle
        50.54  0.00  0.00  1.22  0.00  48.24
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     3.43   109.14   1.29    764      16
avg-cpu: %user %nice %system %iowait %steal %idle
        50.57  0.00  0.00  1.09  0.00  49.35
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     3.00   101.00   0.00    140      0
avg-cpu: %user %nice %system %iowait %steal %idle
        23.49  0.00  0.07  1.58  0.00  74.86
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     1.00   36.57   0.00    256      0
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.07  0.00  0.00  99.64
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     0.49   0.00   4.29    0      44
oOKundOo@instance-1:~
```

```
oOKundOo@instance-1:~
Read 93.79MB Written 62.531MB Total transferred 156.33MB (0.966Mb/sec)
189.86 Requests/sec executed

Test execution summary:
  total time: 52.6965s
  total number of events: 10005
  total time taken by event execution: 102.1383
  per-request statistics:
    min: 0.01ms
    avg: 10.21ms
    max: 268.49ms
    approx. 95 percentile: 35.82ms

Threads fairness:
  events (avg/stddev): 5002.5000/89.50
  execution time (avg/stddev): 51.0692/0.01

# exit
oOKundOo@instance-1:~$ sudo -i
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches
root@instance-1:~# exit
logout
oOKundOo@instance-1:~$ sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
  total time: 37.2222s
  total number of events: 10000
  total time taken by event execution: 37.2191
  per-request statistics:
    min: 3.65ms
    avg: 3.72ms
    max: 38.64ms
    approx. 95 percentile: 3.87ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 37.2191/0.00

oOKundOo@instance-1:~
```

Iostat with 10 iterations every 7 seconds in fileio Mode :-

The screenshot shows two terminal windows side-by-side. The left window displays the output of `iostat -t 10`, showing disk I/O statistics over 10 iterations. The right window shows the output of `sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run`, providing a detailed test execution summary including total time, event count, and percentile statistics.

```
oOKundOo@instance-1:~
iostat -t 10
Linux 4.10.0-33-generic (instance-1) 09/21/2017 _x86_64_ (2 CPU)
avg-cpu: %user %nice %system %iowait %steal %idle
        1.45  0.01  0.11  0.51  0.00  97.91
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     5.53   14.56   582.90   4613732  184657164
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.50  64.03  0.00  35.18
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     242.14   1090.86   684.57   7636    4792
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.87  65.25  0.00  10.60
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     412.86   1826.29   1271.43   12784    8900
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.79  84.14  0.00  14.78
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     402.14   1466.86   1280.00   10128    8960
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.51  93.29  0.00  5.92
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     401.71   1400.00   1279.32   9828    8946
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.94  95.14  0.00  0.63
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     400.14   1399.43   1316.29   9376    9172
avg-cpu: %user %nice %system %iowait %steal %idle
        0.12  0.00  0.58  93.14  0.00  6.07
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     422.00   1378.59   1330.86   9648    9316
avg-cpu: %user %nice %system %iowait %steal %idle
        0.29  0.00  0.58  95.11  0.00  10.02
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     427.86   1401.14   1378.59   9668    9648
avg-cpu: %user %nice %system %iowait %steal %idle
        0.14  0.00  1.01  85.93  0.00  15.95
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     398.29   1375.43   1270.29    9628    8892
avg-cpu: %user %nice %system %iowait %steal %idle
        0.22  0.00  0.00  0.43  0.00  99.35
Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda     1.29   22.29    1.71    156      12
oOKundOo@instance-1:~
```

```
oOKundOo@instance-1:~
sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
oOKundOo@instance-1:~$ sudo -i
root@instance-1:~# echo 3 > /proc/sys/vm/drop_caches
root@instance-1:~# exit
logout
oOKundOo@instance-1:~$ sudo docker run -it csmnapp/ubuntu-sysbench /bin/sh
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960Kb each, 5120Mb total
Creating files for the test...
# sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 40960Kb each
5Gb file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of the test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6003 Read, 4002 Write, 12800 Other = 22805 total
Read 93.79MB Written 62.531MB Total transferred 156.33MB (0.966Mb/sec)
189.86 Requests/sec executed

Test execution summary:
  total time: 52.6965s
  total number of events: 10005
  total time taken by event execution: 102.1383
  per-request statistics:
    min: 0.01ms
    avg: 10.21ms
    max: 268.49ms
    approx. 95 percentile: 35.82ms

Threads fairness:
  events (avg/stddev): 5002.5000/89.50
  execution time (avg/stddev): 51.0692/0.01
```

## QEMU :

Iostat with 11 iterations every 10 seconds in CPU Mode :-

```
oOkundOo@instance-1:~
oOkundOo@instance-1:~$ iostat 10 11
Linux 4.10.0-33-generic (instance-1) 09/21/2017 _x86_64_ (2 CPU)

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          1.55   0.01   0.11   0.47   0.00  97.87

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      5.19    13.42    531.26  3712792  146949528

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          0.30   0.00   0.10   0.30   0.00  99.29

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.20    1.20     0.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          40.17   0.00   0.10   0.10   0.00  98.63

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.70     0.00     0.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.30   0.00   0.20   0.00   0.00  98.90

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.00     0.00     0.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.45   0.00   0.00   0.00   0.00  99.55

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.10     0.00     0.40     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.48   0.00   0.00   0.00   0.00  99.52

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.20     0.00     4.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.51   0.00   0.05   0.00   0.00  99.44

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.00     0.00     0.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.48   0.00   0.05   0.00   0.00  99.47

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.00     0.00     0.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.40   0.00   0.15   0.08   0.00  98.40

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.70     0.00     0.00     0.00     0.00

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          50.33   0.00   0.10   0.00   0.00  99.57

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      0.00     0.00     0.00     0.00     0.00
```

GEMU - Press Ctrl-Alt to exit mouse grab (as superuser)
kunalshira@ubuntu:~\$ sysbench --test=cpu --cpu-max-prime=25000 run
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: 25000

Test execution summary:
total time: 95.1153s
total number of events: 10000
total time taken by event execution: 95.0523s
per-request statistics:
min: 8.71ms
avg: 9.51ms
max: 24.28ms
approx. 95 percentile: 10.82ms

Threads fairness:
events (avg/stddev): 10000.0000/0.00
execution time (avg/stddev): 95.0523/0.00

kunalshira@ubuntu:~\$

Iostat with 12 iterations every 10 seconds in fileio Mode :-

```
oOkundOo@instance-1:~
oOkundOo@instance-1:~$ iostat 10 12
Linux 4.10.0-33-generic (instance-1) 09/21/2017 _x86_64_ (2 CPU)

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          1.56   0.01   0.11   0.47   0.00  97.95

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      5.18    13.42    530.50  3717404  146949188

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          30.97   0.00   2.18   11.81   0.00  55.31

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      150.80   164.00   32795.60  1640     327956

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          35.34   0.00   3.44   13.72   0.00  47.49

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      203.00   0.40   44697.20     4     446972

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.66   0.00   3.33   13.42   0.00  46.39

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      192.71   0.00   41355.84     0     413972

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.55   0.00   5.19   12.42   0.00  47.91

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      189.10   0.00   43029.20     0     430292

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.00   0.00   5.66   13.11   0.00  45.60

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      186.90   0.40   43069.60     4     430696

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.89   0.00   5.28   12.54   0.00  46.89

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      188.30   2.00   41002.40     20    410024

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.10   0.00   2.78   13.65   0.00  47.47

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      210.40   5.60   45098.00     56    450980

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          37.53   0.00   2.58   12.11   0.00  47.75

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      188.10   0.00   41000.00     0     410000

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.73   0.00   2.58   13.87   0.00  47.82

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      167.30   4.40   36956.80     44    369568

avg-cpu:  user  %user  system  %system  iowait  %iowait  idle
          36.81   0.00   3.14   13.06   0.00  46.99

Device:    tps   kB_read/s   kB_wrtn/s   kB_read   kB_wrtn
sda      190.20   1.20   40995.60     12    409956
```

GEMU - Press Ctrl-Alt to exit mouse grab (as superuser)
approx. 95 percentile: 10.82ms

Threads fairness:
events (avg/stddev): 10000.0000/0.00
execution time (avg/stddev): 95.0523/0.00

kunalshirabuntu:~\$ sudo -i
[sudo] password for kunalshirabuntu:
Sorry, try again.
[sudo] password for kunalshirabuntu:
root@ubantu:~# echo 3 > /proc/sys/vm/drop\_caches
root@ubantu:~# exit
logout
kunalshirabuntu:~\$ sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-fd-prepare=sysbench --num-threads=2 --test=fileio --file-total-size=5G --file-test-node=rdrw clear
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 40960K each, 5120Mb total
Creating files for the test...
Running the test with following options:
Number of threads: 2

Extra file open flags: 0
128 files, 40Mb each
5Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!

```

oOKundOo@instance-1: ~
[1] 104154.179.1285901 (instance-1-1 (oOKundOo)) - VNC Viewer
oOKundOo@instance-1: ~
QEMU - Press Ctrl-Alt to exit mouse grab (as superuser)

Number of threads: 2
Extra file open flags: 0
120 files, 40Mb each
5Gb total file size
Block size 16kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random r/w test
Threads started!
Done.

Operations performed: 6006 Read, 4004 Write, 12800 Other = 22810 Total
Read 93.844Mb Written 62.562Mb Total transferred 156.41Mb (1.4629Mb/sec)
93.63 Requests/sec executed

Test execution summary:
    total time: 106.9146s
    total number of events: 10010
    total time taken by event execution: 192.2934
    per-request statistics:
        min: 0.03ms
        avg: 19.21ms
        max: 265.11ms
        approx. 95 percentile: 60.01ms

Threads fairness:
    events (avg/stddev): 5005.0000/41.00
    execution time (avg/stddev): 96.1467/0.06

sysbench 0.4.12: multi-threaded system evaluation benchmark

Removing test files...
sunalishirabuntu: ~

```

## 7.\_ Please understand the performance data, analyze the data, and then present them in an understandable way in your report.

Understanding and Analysis of data is done in section 7. For that used values obtained from one of the many iostat iterations.

### CPU Utilization :-

System	User Level %	Kernel Level %
Native	50.75	0.10
Docker	51.00	0.07
QEMU	50.40	0.15

- **%user:** The percentage of CPU utilization that occurred while executing at the user level (this is the application usage).
- **%nice:** The percentage of CPU utilization that occurred while executing at the user level with *nice* priority.
- **%system:** The percentage of CPU utilization that occurred while executing at the system level (kernel).
- **%iowait:** The percentage of time that the CPU or CPUs were idle during which the system had an outstanding disk I/O request.
- **%steal:** The percentage of time spent in involuntary wait by the virtual CPU or CPUs while the hypervisor was servicing another virtual processor.
- **%idle:** The percentage of time that the CPU or CPUs were idle and the systems did not have an outstanding disk I/O request.

### Device Utilization Report :-

System	tps	kb_read/s	kb_wrtn/s	kb_read	kb_wrtn
Native	458	1485	1498	8912	8988
Docker	427	1401	1378	9808	9648
QEMU	210	5.6	45098	56	450980

- **Tps :** Indicate the number of transfers per second that were issued to the device. A transfer is an I/O request to the device. Multiple logical requests can be combined into a single I/O request to the device. A transfer is of indeterminate size.
- **kb\_read/s :** Indicate the amount of data read from the device expressed in a number of kilobytes per second.
- **kb\_wrtn/s :** Indicate the amount of data written to the device expressed in a number of kilobytes per second.
- **kb\_read :** The total number of kilobytes read.
- **kb\_wrtn :** The total number of kilobytes written.

## **Understandings and Analysis :**

In case of CPU utilization

- User level and Kernel level wise resource usage percentage is almost similar.

In case of Device utilization

- Tps (transfer per second) rate shows that speed of native and docker are very close rate wise. Whereas transfer rate of QEMU fileio is half of the docker container. Hence, according to tps –

Native > Docker >> QEMU

- Kb\_read/s, kb\_wrtn/s, kb\_read, kb\_wrtn value shows that native and docker are very close rate wise.
- Whereas amount of reads done in particular operations native and docker fileio are 160 times that of the QEMU. Hence, according to reads –

Native > Docker >>> QEMU

- Whereas amount of writes done in particular operations the QEMU fileio is 46 times that of native and docker. Hence, according to writes –

QEMU>>> Docker> Native

## **Differences in Virtualization Techniques :**

Sr. No.	Lightweight Virtualization	Heavyweight Virtualization
1-Represents	OS Level Virtualization	H/W Level Virtualization
2-Provisioning	Real-time	Slow
3-Performance	Native	Limited
4-Secure	Fully isolated -> More Secure	Process Level isolation -> less secure
5-Example	Containers – Docker	Virtual Machine - QEMU

## 8. Conclusion

Please refer commands used for testing in detail in the section 5 of the report (results of table are in seconds).

Native System:

Mode	Test1	Test2	Test3	Average
CPU	37.19	37.25	37.41	37.28
FILEIO	39.72	39.61	38.99	39.44

Docker System:

Mode	Test1	Test2	Test3	Average
CPU	37.67	37.83	38.27	37.92
FILEIO	52.69	50.12	50.44	51.08

QEMU System:

Mode	Test1	Test2	Test3	Average
CPU	91.31	91.43	90.85	91.19
FILEIO	113.85	117.86	108.20	113.30

Based upon the results obtained under specific instructions across 3 different scenarios. Table to indicates percentage comparison that how more faster the native is as compared to Docker Container and QEMU System :

Mode	Docker Container	QEMU System
CPU	1.7%	144.6%
Fileio	29.5%	187.2%

Formula used for percent fast comparison :

$$\text{Percent fast} = \frac{T(\text{System\_2}) - T(\text{System\_1})}{T(\text{System\_1})}$$

Where,

$T(\text{system\_1})$  = time taken by system\_1

System\_1 is fast, takes 100, System\_2 is slow, takes 110

According to results obtained from the above tables using same commands or input test cases on every scenarios. I got to the conclusion that ranking wise fastest to slowest.

1. Native System
2. Docker Container
3. QEMU System