

Mini-Project 1 – Lightweight vs. Heavyweight Virtualization Techniques

Google Cloud Environment Setup

1. Go to Compute Engine > VM instances
2. Clicked on Create Instance
3. Given a name to the VM instance as cc-mini-1. Selected the region for the VM as per your location and costing. Keep Machine as General Purpose and Series N1 as selected by default. Selected the machine type as custom to select the configuration as requirement of the min project.

Region ?
Region is permanent

Zone ?
Zone is permanent

Machine configuration ?

Machine family

General-purpose Memory-optimized Compute-optimized

Machine types for common workloads, optimized for cost and flexibility

Series

N1

Powered by Intel Skylake CPU platform or one of its predecessors

Machine type

Custom

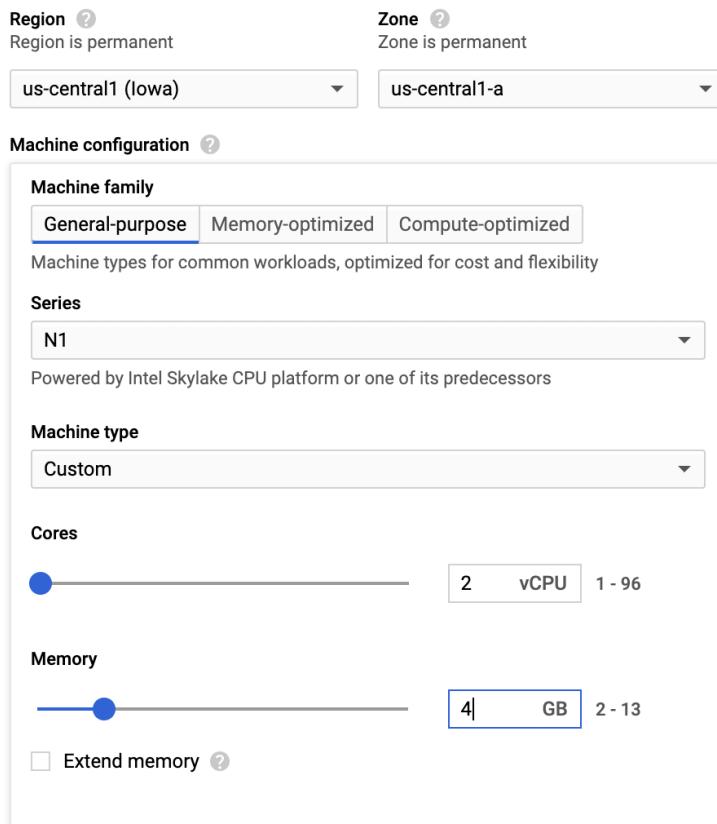
Cores

2 vCPU 1 - 96

Memory

4 GB 2 - 13

Extend memory ?



4. Click on Boot Disk and Selected the public image of the operation system we wish to use. (Ubuntu 16.04 LTS in our case) and the set the Boot Disk Size as 20 GB as per the configuration requirement specified.

Boot disk

Select an image or snapshot to create a boot disk; or attach an existing disk. Can't find what you're looking for? Explore hundreds of VM solutions in [Marketplace](#).

Public images	Custom images	Snapshots	Existing disks
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Show images with Shielded VM features [?](#)

Operating system
Ubuntu

Version
Ubuntu 16.04 LTS

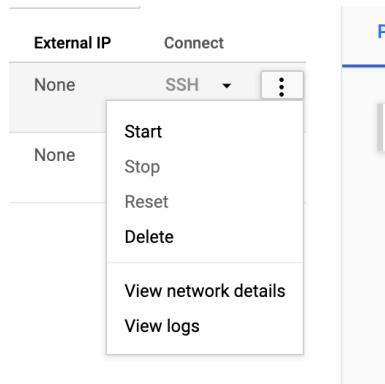
amd64 xenial image built on 2020-02-23

Boot disk type [?](#) **Size (GB)** [?](#)
Standard persistent disk

5. Clicked on Create Instance. Instance gets created as shown in the image below.

<input type="checkbox"/>	Name ^	Zone	Recommendation	In use by	Internal IP	External IP	Connect
<input type="checkbox"/>	cc-mini-1	us-central1-a			10.128.0.3 (nic0)	None	SSH ▼ 

6. Started the instance by clicking on the 3 Dots and clicking on start as shown below.



7. We can now see the instance running.

<input type="checkbox"/>	Name ^	Zone	Recommendation	In use by	Internal IP	External IP	Connect
<input checked="" type="checkbox"/>	cc-mini-1	us-central1-a			10.128.0.3 (nic0)	35.238.190.130	SSH ▼ 

Docker installation inside the VM.

```
saheelraut@cc-mini-1:~$ sudo apt-get update
saheelraut@cc-mini-1:~$ sudo apt-get install \
> apt-transport-https \
> ca-certificates \
> curl \
> gnupg-agent \
> software-properties-common
saheelraut@cc-mini-1:~$ curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key
add -
saheelraut@cc-mini-1:~$ sudo apt-key fingerprint OEBFCD88
saheelraut@cc-mini-1:~$ sudo add-apt-repository \
> "deb [arch=amd64] https://download.docker.com/linux/ubuntu \
> $(lsb_release -cs) \
> stable"
saheelraut@cc-mini-1:~$ sudo apt-get update
saheelraut@cc-mini-1:~$ sudo apt-get install docker-ce docker-ce-cli containerd.io
saheelraut@cc-mini-1:~$ sudo docker run hello-world
```

Steps to enable a docker container.

1. Display all containers (active/inactive)

```
sudo docker container ls -all
```

2. Pulling the ubuntu sysbench docker image from **dockerhub**

```
saheelraut@cc-mini-1:~$ sudo docker pull csminpp/ubuntu-sysbench
```

3. Display all the images present in Docker

```
sudo docker images
```

4. Run the sysbench image

```
saheelraut@cc-mini-1:~$ sudo docker run csminpp/ubuntu-sysbench
```

5. Display all the containers

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
4c1a01889343	csminpp/ubuntu-sysbench	"/bin/bash"	9 seconds ago	Exited (0) 8 seconds ago		wonderful_clarke

6. Run the sysbench container and get interactive bash shell

```
saheelraut@cc-mini-1:~$ sudo docker run -it csminpp/ubuntu-sysbench  
root@100b06e07700:/#
```

The -it instructs Docker to allocate a pseudo-TTY connected to the container's stdin; creating an interactive bash shell in the container

Creating a container

- docker container create is used to create a container in docker.

Steps to Enable QEMU VM

Steps to install QEMU on our native system

```
saheelraut@cc-mini-1:~$sudo apt-get install qemu
```

- Downloading Ubuntu server ISO

```
saheelraut@cc-mini-1:~$wget http://mirror.pnl.gov/releases/16.04/ubuntu-16.04.6-server-  
amd64.iso
```

Creating a disk image

```
saheelraut@cc-mini-1:~$sudo qemu-img create ubuntu.img 10G
```

Installing QEMU VM

```
saheelraut@cc-mini-1:~$sudo qemu-system-x86_64 -hda ubuntu.img -boot d -cdrom ./ubuntu-  
16.04.6-server-amd64.iso -m 1536
```

This will prompt for the installation of the operating system.

After the installation of the operating system, restart the VM to use it.

To use the VM at any later point.

```
saheelraut@cc-mini-1:~$sudo qemu-system-x86_64 -hda ubuntu.img -m 1536
```

Installing sysbench on QEMU VM

```
sudo apt-get install sysbench
```

Performance measure in Docker using sysbench

1. cpu

The cpu is one of the simplest benchmarks in SysBench. In this mode each request consists in calculation of prime numbers up to a value specified by the --cpu-max-primes option. All calculations are performed using 64-bit integers. We have performed the CPU performance benchmark 3 times for max prime number of 20000.

```
root@100b06e07700:/# sysbench --test=cpu --cpu-max-prime=20000 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: 20000

Test execution summary:

total time:	27.2852s
total number of events:	10000
total time taken by event execution:	27.2835
per-request statistics:	
min:	2.68ms
avg:	2.73ms
max:	6.50ms
approx. 95 percentile:	2.83ms

Threads fairness:

events (avg/stddev):	10000.0000/0.00
execution time (avg/stddev):	27.2835/0.00

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 27.28s

2nd Run: 27.35s

3rd Run: 27.31s

Average – 27.31s

2. fileio

This test mode can be used to produce various kinds of file I/O workloads. At the prepare stage SysBench creates a specified number of files with a specified total size, then at the run stage, each thread performs specified I/O operations on this set of files.

Seqwr

- sequential write

```
saheelraut@cc-mini-1:~$ sudo docker run -it csmnpp/ubuntu-sysbench
root@25c1ca63adfd:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqwr prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
root@25c1ca63adfd:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqwr run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 196608 Write, 128 Other = 196736 Total
Read 0b Written 3Gb Total transferred 3Gb (116.27Mb/sec)
7441.31 Requests/sec executed

Test execution summary:
total time: 26.4212s
total number of events: 196608
total time taken by event execution: 332.6432
per-request statistics:
min: 0.01ms
avg: 1.69ms
max: 687.31ms
approx. 95 percentile: 0.04ms

Threads fairness:
events (avg/stddev): 12288.0000/1429.73
execution time (avg/stddev): 20.7902/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 26.42s

2nd Run: 26.33s

3rd Run: 26.27s

Average – 26.34s

seqrewr

- sequential rewrite

```
root@25c1ca63adfd:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrewr prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
root@25c1ca63adfd:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrewr run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential rewrite test
Threads started!
Done.

Operations performed:  0 Read, 196608 Write, 128 Other = 196736 Total
Read 0b  Written 3Gb  Total transferred 3Gb  (118.8Mb/sec)
 7603.31 Requests/sec executed

Test execution summary:
  total time:          25.8582s
  total number of events: 196608
  total time taken by event execution: 323.5361
  per-request statistics:
    min:                0.01ms
    avg:                1.65ms
    max:                456.26ms
    approx. 95 percentile: 0.02ms

Threads fairness:
  events (avg/stddev):   12288.0000/1805.35
  execution time (avg/stddev):  20.2210/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 25.85s

2nd Run: 26.10s

3rd Run: 25.10s

Average – 24.68s

Seqrd

- sequential read

```
root@25c1ca63adfd:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrd prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
root@25c1ca63adfd:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrd run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential read test
Threads started!
Done.

Operations performed: 196608 Read, 0 Write, 0 Other = 196608 Total
Read 3Gb Written 0b Total transferred 3Gb (4.7847Gb/sec)
313569.74 Requests/sec executed

Test execution summary:
  total time:          0.6270s
  total number of events: 196608
  total time taken by event execution: 9.5961
  per-request statistics:
    min:                0.00ms
    avg:                0.05ms
    max:               63.28ms
    approx. 95 percentile: 0.01ms

Threads fairness:
  events (avg/stddev): 12288.0000/422.14
  execution time (avg/stddev): 0.5998/0.01
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 0.627s

2nd Run: 0.677s

3rd Run: 0.628s

Average 0.644

rndrd

- random read

Test 1:

```
root@d71c2d5874a3:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrd prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
root@d71c2d5874a3:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrd run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10072 Read, 0 Write, 0 Other = 10072 Total
Read 157.38Mb Written 0b Total transferred 157.38Mb (3.3947Gb/sec)
222472.82 Requests/sec executed

Test execution summary:
total time: 0.0453s
total number of events: 10072
total time taken by event execution: 0.6142
per-request statistics:
    min: 0.00ms
    avg: 0.06ms
    max: 43.19ms
    approx. 95 percentile: 0.01ms

Threads fairness:
events (avg/stddev): 629.5000/254.49
execution time (avg/stddev): 0.0384/0.01
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 0.0453s

2nd Run: 0.900s

3rd Run: 0.777s

Average - 0.5741

rndwr

Test 1:

```
root@d71c2d5874a3:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndwr prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
root@d71c2d5874a3:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndwr run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb 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 write test
Threads started!
Done.

Operations performed: 0 Read, 10002 Write, 12809 Other = 22811 Total
Read 0b Written 156.28Mb Total transferred 156.28Mb (4.7511Mb/sec)
 304.07 Requests/sec executed

Test execution summary:
  total time:          32.8935s
  total number of events: 10002
  total time taken by event execution: 0.1086
  per-request statistics:
    min:                0.01ms
    avg:                0.01ms
    max:                0.84ms
    approx. 95 percentile: 0.01ms

Threads fairness:
  events (avg/stddev): 625.1250/240.38
  execution time (avg/stddev): 0.0068/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 32.89s

2nd Run: 32.90s

3rd Run: 32.88s

Average - 32.89

Rndrw

Test 1:

```
root@d71c2d5874a3:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrw prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
root@d71c2d5874a3:/# sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb 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: 6001 Read, 4000 Write, 12801 Other = 22802 Total
Read 93.766Mb Written 62.5Mb Total transferred 156.27Mb (11.819Mb/sec)
    756.42 Requests/sec executed

Test execution summary:
    total time:                      13.2215s
    total number of events:           10001
    total time taken by event execution: 0.3454
    per-request statistics:
        min:                          0.00ms
        avg:                          0.03ms
        max:                          79.41ms
        approx. 95 percentile:         0.01ms

Threads fairness:
    events (avg/stddev):           625.0625/292.05
    execution time (avg/stddev):   0.0216/0.03
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 13.22s

2nd Run: 13.09s

3rd Run: 13.164s

Average – 13.15s

Performance measure in QEMU VM using sysbench

1. CPU tests

```
saeel@ubuntu:~$ sysbench --test=cpu --cpu-max-prime=20000 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: 20000

Test execution summary:
  total time:          69.1376s
  total number of events: 10000
  total time taken by event execution: 69.1000
  per-request statistics:
    min:                6.64ms
    avg:                6.91ms
    max:                18.58ms
    approx. 95 percentile: 7.29ms

Threads fairness:
  events (avg/stddev): 10000.0000/0.00
  execution time (avg/stddev): 69.1000/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time
1st Run: 69.13s
2nd Run: 69.27s
3rd Run: 69.15s

Average – 69.183

2. File I/O

Seqwr

```
saheel@ubuntu:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqwr
run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 196608 Write, 128 Other = 196736 Total
Read 0b Written 3Gb Total transferred 3Gb (66.4Mb/sec)
4249.60 Requests/sec executed

Test execution summary:
total time: 46.2651s
total number of events: 196608
total time taken by event execution: 672.0900
per-request statistics:
    min: 0.11ms
    avg: 3.42ms
    max: 172.23ms
    approx. 95 percentile: 20.53ms

Threads fairness:
events (avg/stddev): 12288.0000/306.86
execution time (avg/stddev): 42.0056/0.03
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 46.26s

2nd Run: 44.71s

3rd Run: 45.46s

Average – 45.47

Sqrewr

```
saheel@ubuntu:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqre
ur run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential rewrite test
Threads started!
Done.

Operations performed: 0 Read, 196608 Write, 128 Other = 196736 Total
Read 0b Written 3Gb Total transferred 3Gb (72.538Mb/sec)
4642.42 Requests/sec executed

Test execution summary:
total time: 42.3504s
total number of events: 196608
total time taken by event execution: 649.8858
per-request statistics:
    min: 0.11ms
    avg: 3.31ms
    max: 164.47ms
    approx. 95 percentile: 19.29ms

Threads fairness:
events (avg/stddev): 12288.0000/378.66
execution time (avg/stddev): 40.6179/0.03
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 42.35s

2nd Run: 35.28s

3rd Run: 34.86s

Average – 37.49s

Seqrd

```
saheel@ubuntu:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrd run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential read test
Threads started!
Done.

Operations performed: 196608 Read, 0 Write, 0 Other = 196608 Total
Read 3Gb Written 0b Total transferred 3Gb (65.286Mb/sec)
4178.31 Requests/sec executed

Test execution summary:
total time: 47.0544s
total number of events: 196608
total time taken by event execution: 746.5437
per-request statistics:
    min: 0.02ms
    avg: 3.80ms
    max: 101.40ms
    approx. 95 percentile: 21.92ms

Threads fairness:
events (avg/stddev): 12288.0000/232.60
execution time (avg/stddev): 46.6590/0.06
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 47.05s

2nd Run: 42.41s

3rd Run: 43.73s

Average – 44.39

Rndrd

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

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10000 Read, 0 Write, 0 Other = 10000 Total
Read 156.25Mb Written 0b Total transferred 156.25Mb (2.7117Mb/sec)
    173.55 Requests/sec executed

Test execution summary:
    total time:                      57.6198s
    total number of events:           10000
    total time taken by event execution: 920.4044
    per-request statistics:
        min:                           0.02ms
        avg:                          92.04ms
        max:                          941.36ms
        approx. 95 percentile:         295.81ms

Threads fairness:
    events (avg/stddev):            625.0000/24.62
    execution time (avg/stddev):    57.5253/0.03
```

We will repeat the benchmark 3 times to obtain an average value.

Total time
1st Run: 57.61s
2nd Run: 63.77s
3rd Run: 40.05s

Average 53.81s

rndwr

Test 1:

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

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb 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 write test
Threads started!
Done.

Operations performed: 0 Read, 10205 Write, 12800 Other = 23005 Total
Read 0b Written 159.45Mb Total transferred 159.45Mb (4.7224Mb/sec)
302.23 Requests/sec executed

Test execution summary:
    total time:                      33.7651s
    total number of events:           10205
    total time taken by event execution: 11.5236
    per-request statistics:
        min:                          0.05ms
        avg:                          1.13ms
        max:                          57.67ms
        approx. 95 percentile:         5.70ms

Threads fairness:
    events (avg/stddev):            637.8125/147.85
    execution time (avg/stddev):     0.7202/0.14
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 33.76s

2nd Run: 34.88s

3rd Run: 33.76s

Average 34.13

Rndrw

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

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb 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: 6031 Read, 4011 Write, 12800 Other = 22842 Total
Read 94.234Mb Written 62.672Mb Total transferred 156.91Mb (3.6121Mb/sec)
231.18 Requests/sec executed

Test execution summary:
total time: 43.4389s
total number of events: 10042
total time taken by event execution: 502.5249
per-request statistics:
    min: 0.02ms
    avg: 50.04ms
    max: 539.83ms
    approx. 95 percentile: 236.47ms

Threads fairness:
events (avg/stddev): 627.6250/27.01
execution time (avg/stddev): 31.4078/0.66
```

We will repeat the benchmark 3 times to obtain an average value.

Total time
1st Run: 43.43s
2nd Run: 45.41s
3rd Run: 40.61s

Average 43.15s

Performance measure in Native using sysbench

1. cpu

The cpu is one of the simplest benchmarks in SysBench. In this mode each request consists in calculation of prime numbers up to a value specified by the --cpu-max-primes option. All calculations are performed using 64-bit integers. We have performed the CPU performance benchmark 3 times for max prime number of 20000.

```
saheelraut@cc-mini-1:~$ sysbench --test=cpu --cpu-max-prime=20000 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: 20000

Test execution summary:
  total time:                      28.1102s
  total number of events:          10000
  total time taken by event execution: 28.1069
  per-request statistics:
    min:                            2.76ms
    avg:                            2.81ms
    max:                            4.85ms
    approx. 95 percentile:          2.88ms

Threads fairness:
  events (avg/stddev):           10000.0000/0.00
  execution time (avg/stddev):    28.1069/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 28.11s

2nd Run: 29.34s

3rd Run: 28.65s

Average – 28.7s

2. fileio

seqwr

```
saheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqwr run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential write (creation) test
Threads started!
Done.

Operations performed: 0 Read, 196608 Write, 128 Other = 196736 Total
Read 0b Written 3Gb Total transferred 3Gb (117.3Mb/sec)
7507.36 Requests/sec executed

Test execution summary:
total time: 26.1887s
total number of events: 196608
total time taken by event execution: 321.9761
per-request statistics:
    min: 0.01ms
    avg: 1.64ms
    max: 538.43ms
    approx. 95 percentile: 0.03ms

Threads fairness:
events (avg/stddev): 12288.0000/2053.55
execution time (avg/stddev): 20.1235/0.01
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 26.18s

2nd Run: 26.17s

3rd Run: 26.21s

Average – 26.18s

seqrewr

```
sahheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrewr prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
sahheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrewr run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential rewrite test
Threads started!
Done.

Operations performed:  0 Read, 196608 Write, 128 Other = 196736 Total
Read 0b Written 3Gb Total transferred 3Gb (119.49Mb/sec)
7647.48 Requests/sec executed

Test execution summary:
    total time:          25.7089s
    total number of events: 196608
    total time taken by event execution: 319.7235
    per-request statistics:
        min:                 0.01ms
        avg:                 1.63ms
        max:                635.63ms
        approx. 95 percentile: 0.02ms

Threads fairness:
    events (avg/stddev): 12288.0000/1443.62
    execution time (avg/stddev): 19.9827/0.01
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 25.70s

2nd Run: 25.71s

3rd Run: 25.68s

Average – 25.69s

Seqrd

```
sahelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrd prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
sahelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=seqrd run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing sequential read test
Threads started!
Done.

Operations performed: 196608 Read, 0 Write, 0 Other = 196608 Total
Read 3Gb Written 0b Total transferred 3Gb (6.3536Gb/sec)
416390.35 Requests/sec executed

Test execution summary:
total time: 0.4722s
total number of events: 196608
total time taken by event execution: 6.8439
per-request statistics:
    min: 0.00ms
    avg: 0.03ms
    max: 40.03ms
    approx. 95 percentile: 0.01ms

Threads fairness:
events (avg/stddev): 12288.0000/952.28
execution time (avg/stddev): 0.4277/0.02
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 0.47s

2nd Run: 0.45s

3rd Run: 0.46s

Average – 0.46s

rndrd

```
sahelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrd run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb total file size
Block size 16Kb
Number of random requests for random IO: 10000
Read/Write ratio for combined random IO test: 1.50
Periodic FSYNC enabled, calling fsync() each 100 requests.
Calling fsync() at the end of test, Enabled.
Using synchronous I/O mode
Doing random read test
Threads started!
Done.

Operations performed: 10038 Read, 0 Write, 0 Other = 10038 Total
Read 156.84Mb Written 0b Total transferred 156.84Mb (4.3419Gb/sec)
284548.74 Requests/sec executed

Test execution summary:
    total time:          0.0353s
    total number of events: 10038
    total time taken by event execution: 0.2711
    per-request statistics:
        min:            0.00ms
        avg:            0.03ms
        max:            34.13ms
        approx. 95 percentile: 0.01ms

Threads fairness:
    events (avg/stddev): 627.3750/449.58
    execution time (avg/stddev): 0.0169/0.01
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 0.031s

2nd Run: 0.034s

3rd Run: 0.032s

Average 0.0323s

rndwr

```
saheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndwr prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
saheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndwr run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb 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 write test
Threads started!
Done.

Operations performed: 0 Read, 10000 Write, 12804 Other = 22804 Total
Read 0b Written 156.25Mb Total transferred 156.25Mb (4.7506Mb/sec)
304.04 Requests/sec executed

Test execution summary:
total time: 32.8904s
total number of events: 10000
total time taken by event execution: 0.0921
per-request statistics:
min: 0.01ms
avg: 0.01ms
max: 0.13ms
approx. 95 percentile: 0.01ms

Threads fairness:
events (avg/stddev): 625.0000/294.11
execution time (avg/stddev): 0.0058/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 32.89s

2nd Run: 31.87s

3rd Run: 32.56s

Average – 32.44s

rndrw

```
saheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrw prepare
sysbench 0.4.12: multi-threaded system evaluation benchmark

128 files, 24576Kb each, 3072Mb total
Creating files for the test...
saheelraut@cc-mini-1:~$ sysbench --num-threads=16 --test=fileio --file-total-size=3G --file-test-mode=rndrw run
sysbench 0.4.12: multi-threaded system evaluation benchmark

Running the test with following options:
Number of threads: 16

Extra file open flags: 0
128 files, 24Mb each
3Gb 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: 6001 Read, 4000 Write, 12803 Other = 22804 Total
Read 93.766Mb Written 62.5Mb Total transferred 156.27Mb (11.901Mb/sec)
    761.69 Requests/sec executed

Test execution summary:
    total time:                      13.1301s
    total number of events:           10001
    total time taken by event execution: 0.0871
    per-request statistics:
        min:                          0.00ms
        avg:                          0.01ms
        max:                          0.80ms
        approx. 95 percentile:         0.01ms

Threads fairness:
    events (avg/stddev):            625.0625/203.68
    execution time (avg/stddev):     0.0054/0.00
```

We will repeat the benchmark 3 times to obtain an average value.

Total time

1st Run: 13.13s

2nd Run: 13.05s

3rd Run: 13.53s

Average – 13.23s

	Docker Container	QEMU VM	Native
CPU	27.31s	69.13s	28.7s
seqwr	26.34s	45.47s	26.18s
seqrewr	24.68s	37.49s	25.69s
seqrd	0.644s	44.39s	0.46s
rndrd	0.5741s	53.81s	0.0323s
rndwr	32.89s	34.13	32.44s
rndrw	13.15s	43.15	13.23s

From the above table we observe that the CPU and fileio performance in native and docker containers is much better than a QEMU Virtual machine.

We will be using iostat to collect performance data.

CPU utilization when idle

```
saheelraut@cc-mini-1:~$ iostat
Linux 4.15.0-1055-gcp (cc-mini-1)        02/28/2020      _x86_64_      (2 CPU)

avg-cpu: %user  %nice  %system  %iowait  %steal  %idle
          0.75    0.00   1.24     4.32    0.00  93.68

Device:      tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop0        0.00      0.00       0.00         8          0
sda         67.58    109.34   12537.53   422028  48391609
```

User level CPU utilization 0.75%

Kernel level CPU utilization 1.24%

CPU utilization when task under execution

```
saheelraut@cc-mini-1:~$ iostat
Linux 4.15.0-1055-gcp (cc-mini-1)        02/28/2020      _x86_64_      (2 CPU)

avg-cpu: %user  %nice  %system  %iowait  %steal  %idle
          1.01    0.00   1.13     3.90    0.00  93.96

Device:      tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop0        0.00      0.00       0.00         8          0
sda         61.04    98.87   11319.62   422684  48392041
```

User level CPU utilization 1.01%

Kernel level CPU utilization 1.13%

fileio

```
saheelraut@cc-mini-1:~$ iostat -d
Linux 4.15.0-1055-gcp (cc-mini-1)        02/28/2020      _x86_64_      (2 CPU)

Device:      tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop0        0.00      0.00       0.00         8          0
sda         51.73    83.74   9587.07   422684  48393113
```

when rndrw under execution

```
saheelraut@cc-mini-1:~$ iostat -d
Linux 4.15.0-1055-gcp (cc-mini-1)        02/28/2020      _x86_64_      (2 CPU)

Device:      tps      kB_read/s      kB_wrtn/s      kB_read      kB_wrtn
loop0        0.00        0.00        0.00            8            0
sda         55.02       80.30     9805.36    422684    51615313
```

tps Indicate the number of transfers per second that were issued to the device. When a read write operation is performed the tps increases indicating the data written onto the disk.
The kB_read and kB_wrtn indicates the data being read and written to the disk.