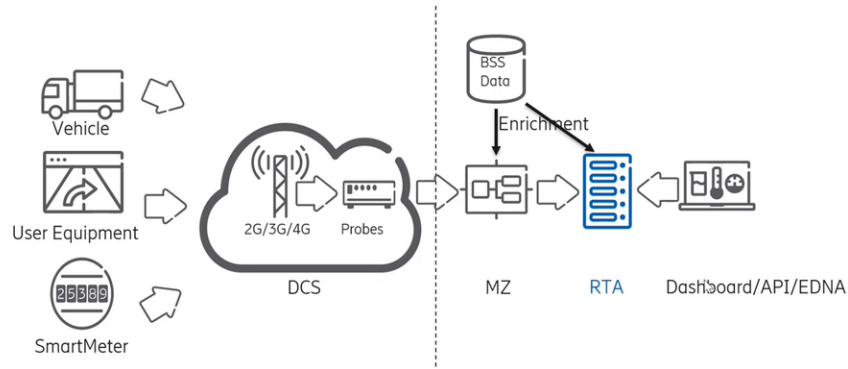


A Comprehensive Survey on the Use of Hypervisors

About Me



Real Time Analytics (RTA) component in IoT Accelerator Platform

Tech Stack

OpenShift - Two clusters; One cluster 100% RTA components while few RTA services running in other cluster

On-premises Hardware /VMWare ESXi type 1 hypervisor / RHEL / Docker and OpenShift

Elasticsearch and Kibana

Grafana & Prometheus - Monitoring

REST APIs, Postman

Data flow

Kafka → Subscribed to a topic to receive XDRs → ETL flow → Elasticsearch → Portal, Rest APIs

Virtualization

What is virtualization?

- Virtual representation of any hardware resources (**servers, storages, networks**)
- Abstracting physical hardware functionality into a software.
- Hypervisors (aka Virtual Machine Monitors) and virtual machines are components of virtualization.

Why virtualization?

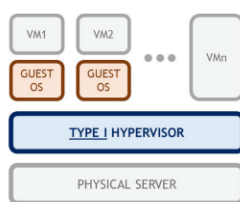
- Virtualization helps to use hardware resources efficiently
- Virtualization enables infrastructure-as-a-service (cloud computing services)

(Hardware) Virtualization types

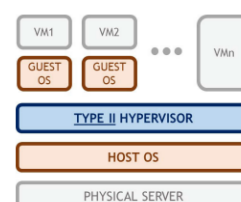
- Server virtualization - refers to physical servers found in data centers, mainly x86 architectures
- Storage virtualization - refers to physical storage hardware devices such as NAS, SAN found in data centers
- Network virtualization - refers to computer network with elements such as switches, routers and firewalls
- Multicore SoC virtualization - refers to systems-on-chip, mainly Arm and x86

Hypervisors Classification

Based on host Environment



Type 1 / Bare-Metal



Type 2

Based on Virtualization type:

Full virtualization

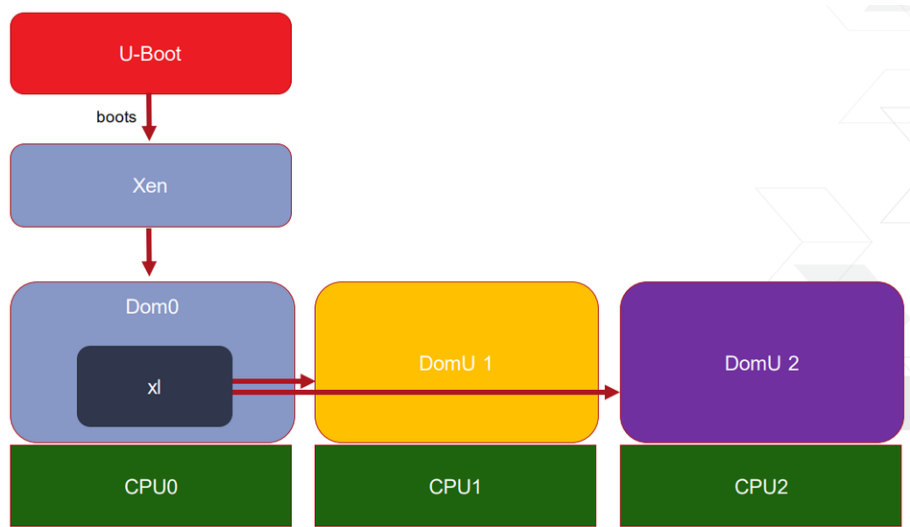
Paravirtualization

Type II hypervisors

VirtualBox

Type I hypervisors (bare-metal hypervisors)

XEN Hypervisor



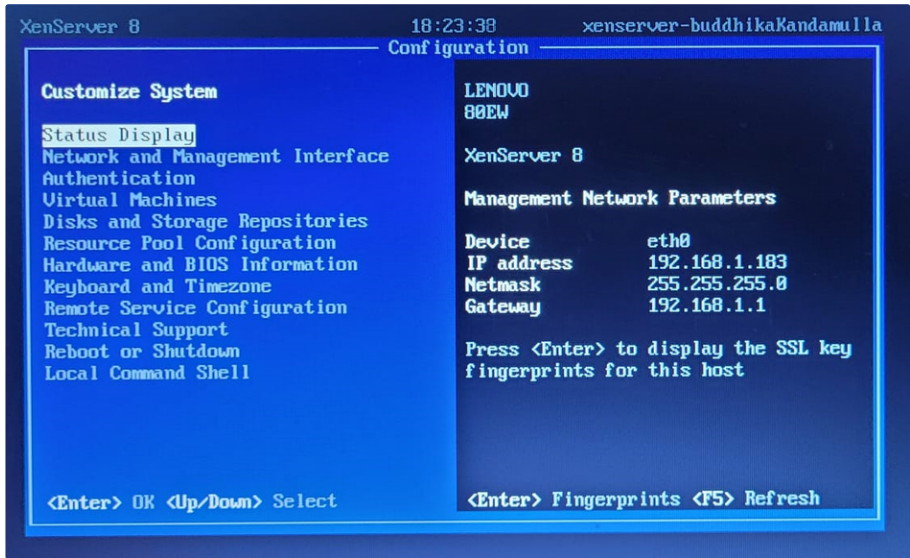
[XPDDS19 Keynote: Xen Dom0-less - Stefano Stabellini, Principal Engineer, Xilinx](#)

Demo - Xen Hypervisor

[Xen Project Software Overview - Xen](#)

Step1: XenServer 8 installation on a old laptop

Doc.: [Quick start](#) | [XenServer 8](#) | [Xen Project Software Overview - Xen](#) | [XenServer 8 Public Preview and Trial Edition](#)

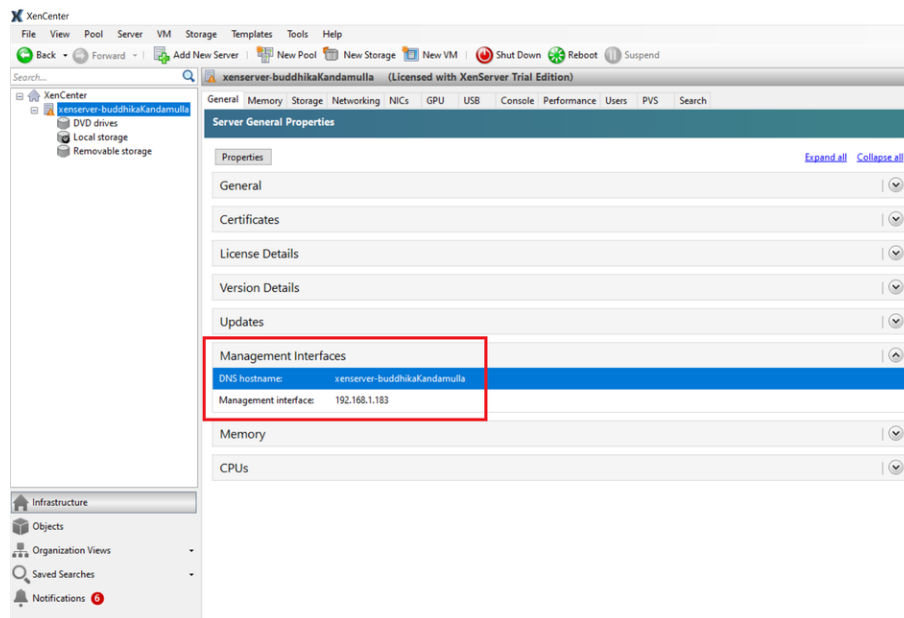


XenServer User Interface

```
[root@xenserver-buddhikaKandamulla ~]# cat /etc/os-release
NAME="XenServer"
VERSION="8.3.60"
ID="xenenterprise"
ID_LIKE="centos rhel fedora"
VERSION_ID="8.3.60"
PRETTY_NAME="XenServer 8"
ANSI_COLOR="0;31"
HOME_URL="http://xenserver.org/"
BUG_REPORT_URL="https://bugs.xenserver.org/"
[root@xenserver-buddhikaKandamulla ~]#
```

DOM0 OS version of XenServer

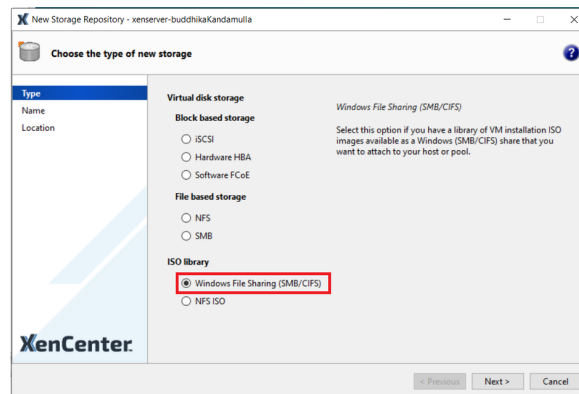
Step2: XenCenter 2023.3.1 installation on user laptop and add server



XenCenter Graphical User Interface

Step3: Mounting Guest OS image to XenServer

❌ Option 1 - Add a shared folder with ISO files from user laptop to XenServer



✅ Option 2- Create ISO library on XenServer itself [Xenserver - Add a Local ISO repository](#)

scp ISO image to XenServer

```
1 bdy@bdy:/mnt/c/xen_iso$ scp ubuntu-20.04.6-live-server-amd64.iso root@192.168.1.183:/media/cdrom/
2 .....
3 ubuntu-20.04.6-live-server-amd64.iso                                100% 1418MB   9.6MB/s   02:28
```

ssh into the XenServer and verify

```
1 bdy@bdy:~$ ssh root@192.168.1.183
2
3 [root@xenserver-buddhikaKandamulla ~]# ls -al /media/cdrom/
4 -rwxr-xr-x 1 root root 1487339520 Sep 20 17:50 ubuntu-20.04.6-live-server-amd64.iso
```

Add /media/cdrom as a ISO-type Image Storage Repository in XenServer:

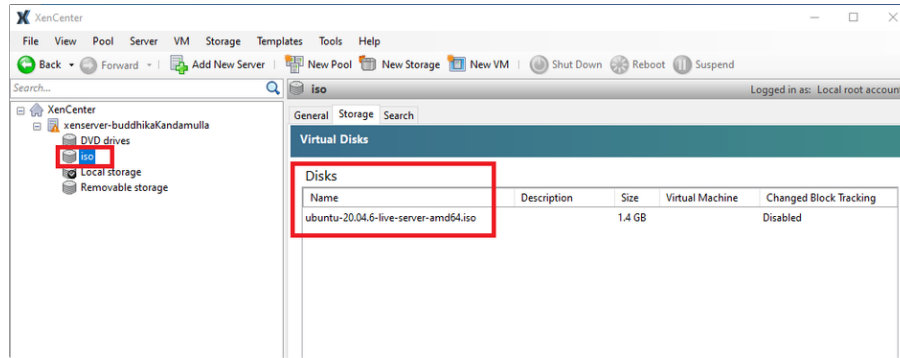
```
1 [root@xenserver-buddhikaKandamulla cdrom]# xe sr-create name-label="iso" type=iso device-config:location=/media/cdrom device-config
2 4521de1b-eb47-c9ca-df43-81da049ee49e
```

List Storage Repositories in the XenServer:

```
1 [root@xenserver-buddhikaKandamulla cdrom]# xe sr-list
2 ...
3 uuid ( R0)                : 4521de1b-eb47-c9ca-df43-81da049ee49e
4   name-label ( RW): iso
5   name-description ( RW):
6     host ( R0): xenserver-buddhikaKandamulla
```

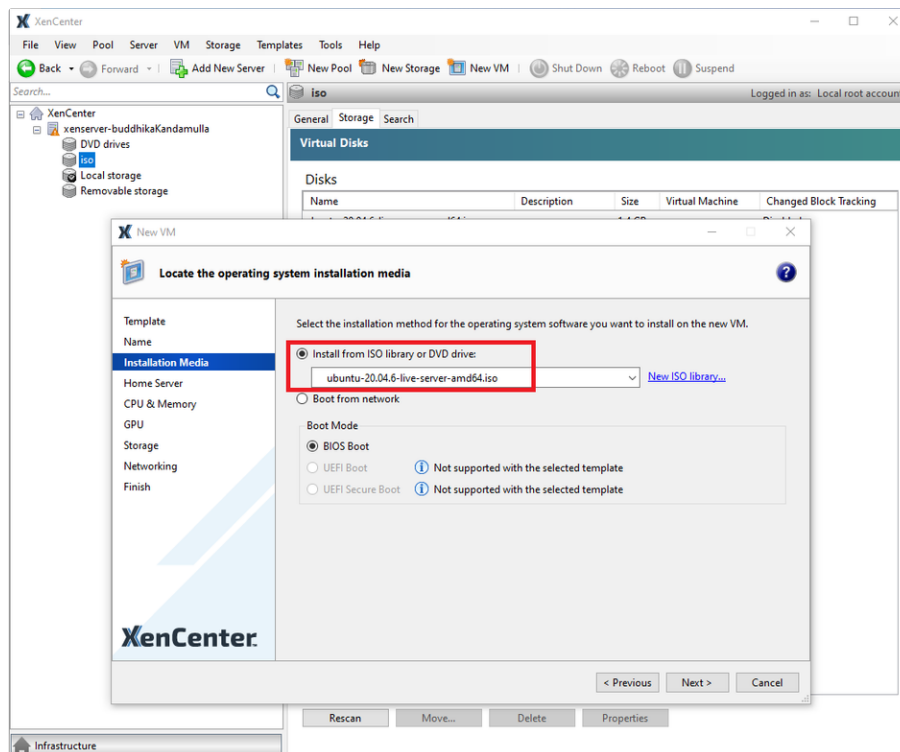
```
7 type ( R0): iso
8 content-type ( R0): iso
```

ISO Image Storage Repository XenCenter:



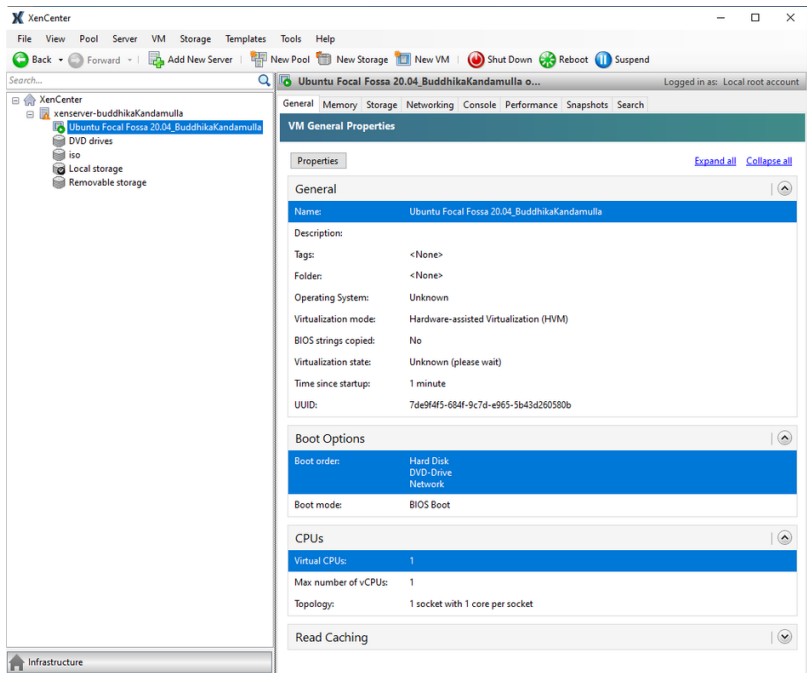
ISO Image Storage Repository mount

Step 4: Create a VMs



Installation Media selection step to choose ISO image during VM creation in XenCenter

VM successfully created:



General info about installed VM in XenCenter

Step 5: Install Docker Daemon [Docker](#)



VM with Docker installed

Step 6: Install Phoronix Test Suite as benchmarking tool [Phoronix Test Suite - Download](#)

Containers & Virtual machines - A performance, resource & power consumption comparison

Downloading Phoronix Test Suite

```
1 bdy@xenvmdebian3-buddhika:~$ cd benchmark_test/
2
3 # Get the installation package
4 bdy@xenvmdebian3-buddhika:~/benchmark_test$ wget https://phoronix-test-suite.com/releases/repo/pts.debian/files/phoronix-test-suite_10ite_10.8.4_all.deb
5
6 bdy@xenvmdebian3-buddhika:~/benchmark_test$ ls
7 phoronix-test-suite_10.8.4_all.deb
```

Installing Phoronix Test Suite

```
1 # Install Phoronix Test Suite
2 $ sudo dpkg -i phoronix-test-suite_10.8.4_all.deb
3
4 # Install missing dependencies if necessary
5 $ sudo apt --fix-broken install
```

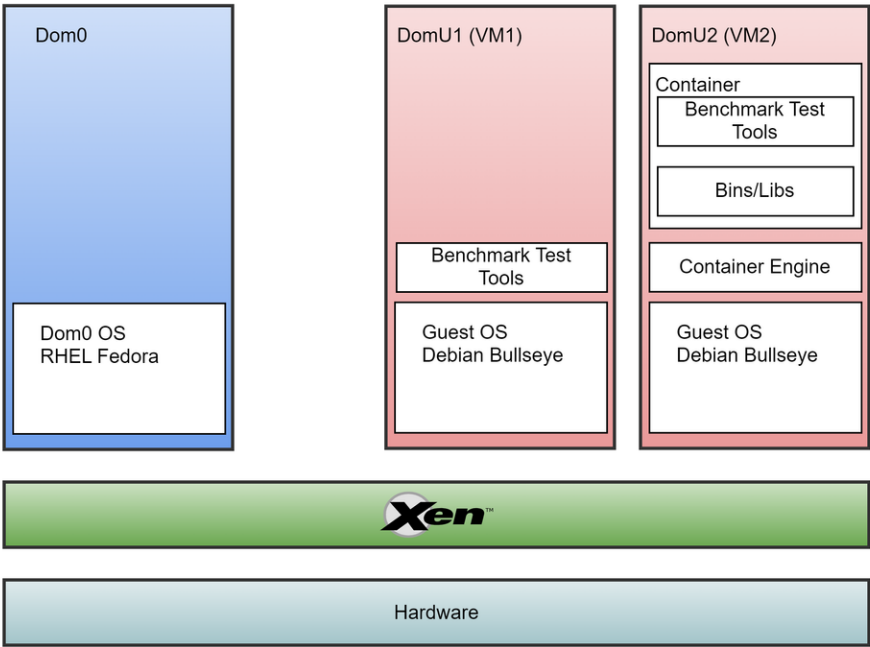
Tests to be installed in next steps:

Hardware component	Benchmark Test from Phoronix Test Suite
Processor	N-Queens
Memory	RAMspeed SMP
Disk	dbench

Step 7: Create base snapshot

Using this base snapshot two VMs (VM1 and VM2) are created In following steps.

VM1 - benchmark tests on VM



Step 8: VM1 - benchmark tests on VM

Create VM from base snapshot

Benchmarking

N-Queens

```

1 bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite install pts/n-queens
2
3 bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite run pts/n-queens-1.2.1
4 ...
5 N-Queens 1.0:
6   pts/n-queens-1.2.1
7   Test 1 of 1
8   Estimated Trial Run Count:    3
9   Estimated Time To Completion: 36 Minutes [23:56 EEST]
10      Started Run 1 @ 23:21:05
11      Started Run 2 @ 23:26:59
12      Started Run 3 @ 23:32:52
13
14   Elapsed Time:
15     349.545
16     349.602
17     349.483
18
19   Average: 349.543 Seconds
20   Deviation: 0.02%
21
22   N-Queens 1.0
23   Elapsed Time
24   Seconds < Lower Is Better
25   N-Queens_24Sept23 . 349.54
    
```

RAMspeed SMP

```

1 bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite install pts/ramspeed-1.4.3
2
3 bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite run pts/ramspeed-1.4.3
4 ...
5 RAMspeed SMP 3.5.0:
6   pts/ramspeed-1.4.3
7   Memory Test Configuration
8     1: Copy
9     2: Scale
10    3: Add
    
```

```

11      4: Triad
12      5: Average
13      6: Test All Options
14      ** Multiple items can be selected, delimit by a comma. **
15      Type: 1,3
16
17      1: Integer
18      2: Floating Point
19      3: Test All Options
20      ** Multiple items can be selected, delimit by a comma. **
21      Benchmark: 2
22
23 RAMspeed SMP 3.5.0:
24 pts/ramspeed-1.4.3 [Type: Add - Benchmark: Floating Point]
25 Test 1 of 2
26 Estimated Trial Run Count:      3
27 Estimated Test Run-Time:      6 Minutes
28 Estimated Time To Completion: 12 Minutes [00:00 EEST]
29 Started Run 1 @ 23:48:57
30 Started Run 2 @ 23:52:43
31 Started Run 3 @ 23:56:27
32
33 Type: Add - Benchmark: Floating Point:
34      8161.03
35      8157.81
36      8156.16
37
38 Average: 8158.33 MB/s
39 Deviation: 0.03%
40
41 RAMspeed SMP 3.5.0:
42 pts/ramspeed-1.4.3 [Type: Copy - Benchmark: Floating Point]
43 Test 2 of 2
44 Estimated Trial Run Count:      3
45 Estimated Time To Completion: 12 Minutes [00:11 EEST]
46 Started Run 1 @ 00:00:20
47 Started Run 2 @ 00:04:05
48 Started Run 3 @ 00:07:50
49
50 Type: Copy - Benchmark: Floating Point:
51      7418.64
52      7398.55
53      7401.9
54
55 Average: 7406.36 MB/s
56 Deviation: 0.15%
57
58 RAMspeed SMP 3.5.0
59 Type: Add - Benchmark: Floating Point
60 MB/s > Higher Is Better
61 RAMspeed-SMP Test . 8158.33
62
63 RAMspeed SMP 3.5.0
64 Type: Copy - Benchmark: Floating Point
65 MB/s > Higher Is Better
66 RAMspeed-SMP Test . 7406.36

```

Dbench

```

1 bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite install pts/dbench
2
3 bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite run pts/dbench-1.0.2
4 ...
5 Dbench 4.0:
6 pts/dbench-1.0.2
7 Disk Test Configuration
8      1: 1
9      2: 6
10     3: 12
11     4: 48
12     5: 128
13     6: 256
14     7: Test All Options
15     ** Multiple items can be selected, delimit by a comma. **
16     Client Count: 2,4
17
18 Dbench 4.0:
19 pts/dbench-1.0.2 [Client Count: 6]
20 Test 1 of 2
21 Estimated Trial Run Count:      3
22 Estimated Test Run-Time:      45 Minutes
23 Estimated Time To Completion: 2 Hours, 15 Minutes [02:43 EEST]
24 Started Run 1 @ 00:28:32

```

```

25         Started Run 2 @ 00:40:36
26         Started Run 3 @ 00:52:41
27
28         Client Count: 6:
29             255.977
30             257.834
31             267.091
32
33         Average: 260.301 MB/s
34         Deviation: 2.29%
35
36 Dbench 4.0:
37     pts/dbench-1.0.2 [Client Count: 48]
38     Test 2 of 2
39     Estimated Trial Run Count:    3
40     Estimated Test Run-Time:    37 Minutes
41     Estimated Time To Completion: 1 Hour, 13 Minutes [02:16 EEST]
42         Started Run 1 @ 01:04:52
43         Started Run 2 @ 01:16:58
44         Started Run 3 @ 01:29:04
45
46         Client Count: 48:
47             52.143
48             52.385
49             53.8318
50
51         Average: 52.7866 MB/s
52         Deviation: 1.73%
53
54         Dbench 4.0
55         Client Count: 6
56         MB/s > Higher Is Better
57         dbench disk benchmark test on XenVM . 260.30
58
59         Dbench 4.0
60         Client Count: 48
61         MB/s > Higher Is Better
62         dbench disk benchmark test on XenVM . 52.79

```

Step 9: VM2 - benchmark tests on Docker container running on top of VM

Create VM2 from base snapshot with higher CPU, RAM and Disk than VM1

 VM to run docker container has increased hardware allocation compared to previous VM. When Docker container with hardware limitations similar to previous VM

Expand the partition and filesystem

```

1 #Use PARTition Editor utility to expand the partition
2 sudo parted /dev/xvda
3     resizepart
4     quit
5
6 #Resize the filesystem
7 sudo resize2fs /dev/xvda1

```

```

1 bdy@vm2:~$ df -h
2 Filesystem      Size  Used Avail Use% Mounted on
3 /dev/xvda1      8.9G  6.0G  2.5G  72% /
4
5 bdy@vm2:~$ lsblk
6 NAME        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
7 xvda        202:0    0   20G  0 disk
8 └─xvda1     202:1    0    9G  0 part /
9 └─xvda2     202:2    0    1K  0 part
10 └─xvda5     202:5    0  975M  0 part [SWAP]
11
12 bdy@vm2:~$ sudo parted /dev/xvda
13 GNU Parted 3.4
14 Using /dev/xvda
15
16 (parted) print
17
18 Number  Start   End     Size    Type     File system  Flags
19  1      1049kB  9713MB  9712MB  primary  ext4
20  2      9714MB  10.7GB  1022MB  extended
21  5      9714MB  10.7GB  1022MB  logical  linux-swap(v1)
22
23 (parted) rm 2
24
25 (parted) rm 5
26
27 (parted) resizepart 1 18GB
28

```



```

29 (parted) print
30 Number Start End Size Type File system Flags
31 1 1049kB 18.0GB 18.0GB primary ext4
32
33 (parted) quit
34
35 bdy@vm2:~$ lsblk
36 NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
37 sr0 11:0 1 389M 0 rom
38 xvda 202:0 0 20G 0 disk
39 └─xvda1 202:1 0 16.8G 0 part /
40
41 bdy@vm2:~$ sudo resize2fs /dev/xvda1
42 [sudo] password for bdy:
43 resize2fs 1.46.2 (28-Feb-2021)
44 Filesystem at /dev/xvda1 is mounted on /; on-line resizing required
45 old_desc_blocks = 2, new_desc_blocks = 3
46 The filesystem on /dev/xvda1 is now 4394275 (4k) blocks long.
47
48 bdy@vm2:~$ df -h
49 Filesystem Size Used Avail Use% Mounted on
50 /dev/xvda1 17G 6.0G 9.7G 38% /

```

VM1 - benchmark tests on VM

```

bdy@vm1:~/benchmark_test$ phoronix-test-suite system-info

Phoronix Test Suite v10.8.4
System Information

PROCESSOR: Intel Core i3-5005U
Core Count: 1
Extensions: SSE 4.2 + AVX2 + AVX + RDRAND + FSGSBASE
Cache Size: 3 MB
Microcode: 0x2f
Core Family: Broadwell

GRAPHICS: bochs-drmdrmfb
Screen: 1024x768

MOTHERBOARD: Xen HVM domU v4.13
BIOS Version: 4.13
Chipset: Intel 440FX 82441FX PMC

MEMORY: 938MB

DISK: 9GB
File-System: ext4
Mount Options: errors=remount-ro relatime rw
Disk Scheduler: MQ-DEADLINE
Disk Details: Block Size: 4096

OPERATING SYSTEM: Debian 11
Kernel: 5.10.0-25-amd64 (x86_64)

Desktop: GNOME Shell 3.38.6

Display Server: X Server

System Layer: Xen HVM domU 4.13

```

VM2 - benchmark tests on Docker container running on top of VM

```

bdy@vm2:~/benchmark_test$ phoronix-test-suite system-info

Phoronix Test Suite v10.8.4
System Information

PROCESSOR: 2 x Intel Core i3-5005U
Core Count: 2
Extensions: SSE 4.2 + AVX2 + AVX + RDRAND + FSGSBASE
Cache Size: 6 MB
Microcode: 0x2f
Core Family: Broadwell

GRAPHICS: bochs-drmdrmfb
Screen: 1024x768

MOTHERBOARD: Xen HVM domU v4.13
BIOS Version: 4.13
Chipset: Intel 440FX 82441FX PMC

MEMORY: 2048MB

DISK: 17GB
File-System: ext4
Mount Options: errors=remount-ro relatime rw
Disk Scheduler: MQ-DEADLINE
Disk Details: Block Size: 4096

OPERATING SYSTEM: Debian 11
Kernel: 5.10.0-25-amd64 (x86_64)

Desktop: GNOME Shell 3.38.6

Display Server: X Server

System Layer: Xen HVM domU 4.13

```

Pull docker image of same OS version

```

1 bdy@vm2:~$ sudo docker pull debian:bullseye
2
3 bdy@vm2:~$ sudo docker images
4 REPOSITORY TAG IMAGE ID CREATED SIZE
5 debian bullseye 909f4919a453 6 days ago 124MB

```

Run the Docker container mounting ~/benchmark_test as a volume to the container

--cpus specify maximum amount of CPU resources the container can use

--memory specify maximum amount of memory the container can use

```

1 #Set Maximum Memory Access and CPU Usage
2 bdy@vm2:~/benchmark_test$ sudo docker run -it --name=debian_xen \
3 > --volume ~/benchmark_test:/v \
4 > --cpus="1.0" \
5 > --memory="1g" \
6 > debian:bullseye
7 root@5323995f8aad:/v#

```

Installing Phoronix Test Suite in the container

```

1 root@5323995f8aad:/v# apt-get update
2
3 root@5323995f8aad:/v# apt-get upgrade
4
5 root@5323995f8aad:/v# apt --fix-broken install

```

```
6
7 root@5323995f8aad:/v# dpkg -i phoronix-test-suite_10.8.4_all.deb
```

Docker container with installed Phoronix Test Suite v10.8.4

```
root@5323995f8aad:/v# phoronix-test-suite system-info

Phoronix Test Suite v10.8.4
System Information

PROCESSOR:          2 x Intel Core i3-5005U
Core Count:         2
Extensions:         SSE 4.2 + AVX2 + AVX + RDRAND + FSGSBASE
Cache Size:         6 MB
Microcode:          0x2F
Core Family:        Broadwell

GRAPHICS:            bochs-drmfb
Screen:             1024x768

MOTHERBOARD:        Xen HVM domU v4.13
BIOS Version:        4.13

MEMORY:             2048MB

DISK:               17GB
File-System:         overlayfs

OPERATING SYSTEM:   Debian GNU/Linux 11
Kernel:             5.10.0-25-amd64 (x86_64)

System Layer:        Xen HVM domU 4.13
```

While following benchmark tests running in the container, container's resource utilization verified:

```
1 bdy@vm2:~$ sudo docker stats
2 CONTAINER ID   NAME          CPU %      MEM USAGE / LIMIT   MEM %      NET I/O       BLOCK I/O   PIDS
3 5323995f8aad   debian_xen    100.73%    121.9MiB / 1GiB     11.90%     157MB / 291kB   223MB / 45.9GB  18
```

Benchmarking

N-Queens

```
1 root@5323995f8aad:/v# phoronix-test-suite run pts/n-queens-1.2.1
2 N-Queens 1.0:
3 pts/n-queens-1.2.1
4 Test 1 of 1
5 Estimated Trial Run Count: 3
6 Estimated Time To Completion: 23 Minutes [14:20 UTC]
7 Started Run 1 @ 13:58:11
8 Started Run 2 @ 14:05:47
9 Started Run 3 @ 14:13:14
10
11 Elapsed Time:
12 451.522
13 443.628
14 442.262
15
16 Average: 445.804 Seconds
17 Deviation: 1.12%
18
19 N-Queens 1.0
20 Elapsed Time
21 Seconds < Lower Is Better
22 NQueen-VM2 . 445.80
```

RAMspeed SMP

```
1 root@5323995f8aad:/v# phoronix-test-suite run pts/ramspeed-1.4.3
2
3 RAMspeed SMP 3.5.0:
4 pts/ramspeed-1.4.3
5 Memory Test Configuration
6 1: Copy
7 2: Scale
8 3: Add
9 4: Triad
10 5: Average
11 6: Test All Options
12 ** Multiple items can be selected, delimit by a comma. **
13 Type: 1,3
14
15 1: Integer
16 2: Floating Point
17 3: Test All Options
18 ** Multiple items can be selected, delimit by a comma. **
19 Benchmark: 2
20
```

```
21 RAMspeed SMP 3.5.0:
22   pts/ramspeed-1.4.3 [Type: Add - Benchmark: Floating Point]
23   Test 1 of 2
24   Estimated Trial Run Count:    3
25   Estimated Test Run-Time:    6 Minutes
26   Estimated Time To Completion: 12 Minutes [14:45 UTC]
27     Started Run 1 @ 14:33:22
28     Started Run 2 @ 14:38:34
29     Started Run 3 @ 14:43:50
30
31   Type: Add - Benchmark: Floating Point:
32     5766.53
33     5665.42
34     5524.49
35
36   Average: 5652.15 MB/s
37   Deviation: 2.15%
38
39 RAMspeed SMP 3.5.0:
40   pts/ramspeed-1.4.3 [Type: Copy - Benchmark: Floating Point]
41   Test 2 of 2
42   Estimated Trial Run Count:    3
43   Estimated Time To Completion: 16 Minutes [15:05 UTC]
44     Started Run 1 @ 14:49:21
45     Started Run 2 @ 14:54:48
46     Started Run 3 @ 15:00:13
47
48   Type: Copy - Benchmark: Floating Point:
49     5295.3
50     5427.32
51     5342.62
52
53   Average: 5355.08 MB/s
54   Deviation: 1.25%
55
56   RAMspeed SMP 3.5.0
57   Type: Add - Benchmark: Floating Point
58   MB/s > Higher Is Better
59   RAMspeed_VM2 . 5652.15
60
61   RAMspeed SMP 3.5.0
62   Type: Copy - Benchmark: Floating Point
63   MB/s > Higher Is Better
64   RAMspeed_VM2 . 5355.08
```

Dbench

```
1 root@5323995f8aad:/v# phoronix-test-suite run pts/dbench-1.0.2
2 ...
3 Dbench 4.0:
4   pts/dbench-1.0.2
5   Disk Test Configuration
6     1: 1
7     2: 6
8     3: 12
9     4: 48
10    5: 128
11    6: 256
12    7: Test All Options
13    ** Multiple items can be selected, delimit by a comma. **
14    Client Count: 2,4
15
16 Dbench 4.0:
17   pts/dbench-1.0.2 [Client Count: 6]
18   Test 1 of 2
19   Estimated Trial Run Count:    3
20   Estimated Test Run-Time:    45 Minutes
21   Estimated Time To Completion: 1 Hour, 30 Minutes [16:46 UTC]
22     Started Run 1 @ 15:16:52
23     Started Run 2 @ 15:28:57
24     Started Run 3 @ 15:41:01
25
26   Client Count: 6:
27     170.2
28     169.197
29     168.236
30
31   Average: 169.211 MB/s
32   Deviation: 0.58%
33
34 Dbench 4.0:
35   pts/dbench-1.0.2 [Client Count: 48]
36   Test 2 of 2
```

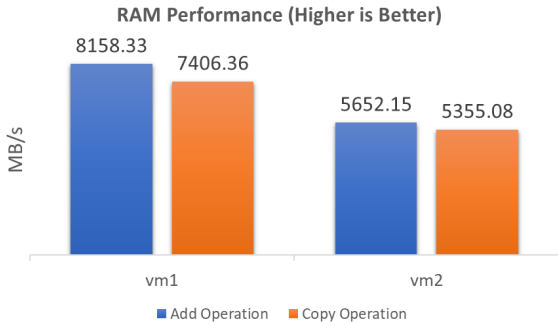
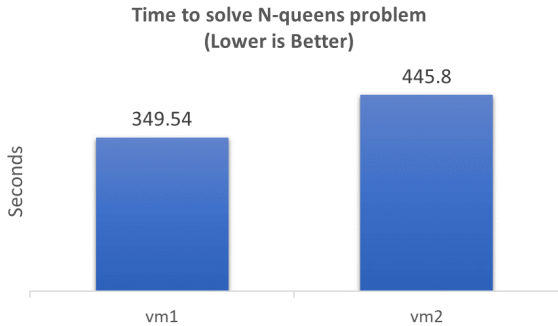
```

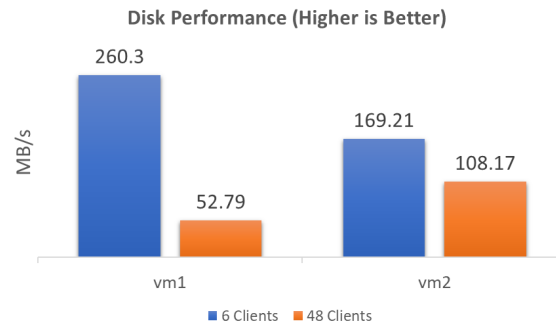
37 Estimated Trial Run Count: 3
38 Estimated Time To Completion: 37 Minutes [16:29 UTC]
39 Started Run 1 @ 15:53:13
40 Started Run 2 @ 16:05:19
41 Started Run 3 @ 16:17:24
42
43 Client Count: 48:
44 105.816
45 109.801
46 108.894
47
48 Average: 108.170 MB/s
49 Deviation: 1.93%
50
51 Dbench 4.0
52 Client Count: 6
53 MB/s > Higher Is Better
54 Dbench_VM2 . 169.21
55 Dbench 4.0
56 Client Count: 48
57 MB/s > Higher Is Better
58 Dbench_VM2 . 108.17

```

Step 10 - Test result comparison

	vm1	vm2
N-Queens 1.0 (Lower Is Better)	349.54 Seconds	445.80 Seconds
RAMspeed SMP 3.5.0 (Higher Is Better)	Add: 8158.33 MB/s Copy: 7406.36 MB/s	Add: 5652.15 MB/s Copy: 5355.08 MB/s
Dbench 4.0 (Higher Is Better)	Client Count 6: 260.30 MB/s Client Count 48: 52.79 MB/s	Client Count 6: 169.21 MB/s Client Count 48: 108.17 MB/s





Summery

<add>

Future works

OpenStack Ironic

