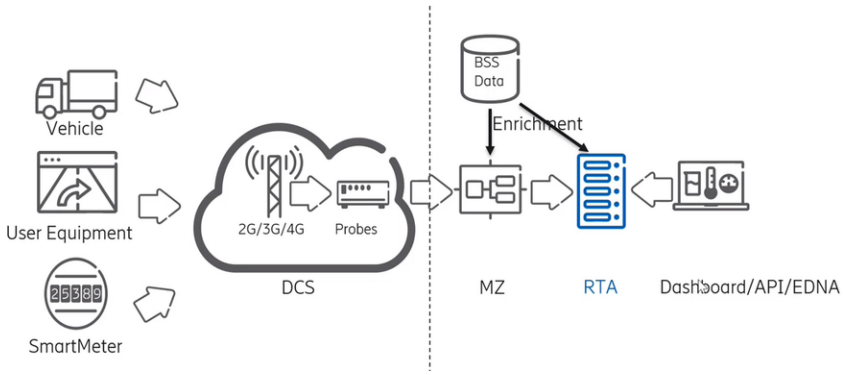
# A Comprehensive Survey on the Use of Hypervisors

## 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?**

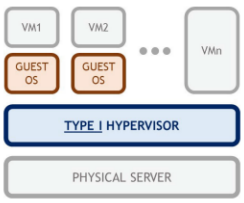
- Virtualization helps to use hardware resources efficiently
- Virtualization enables infrastructure-as-a-service (cloud computing services)

**(Hardware) Virtualization types**

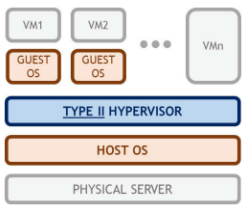
- Server virtualization - refers to physical servers found in data centers, mainly x86 architectures
- Storage virtualization - refers to physical storage hardware devices such as NAS, SAN found in data centers
- Network virtualization - refers to computer network with elements such as switches, routers 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

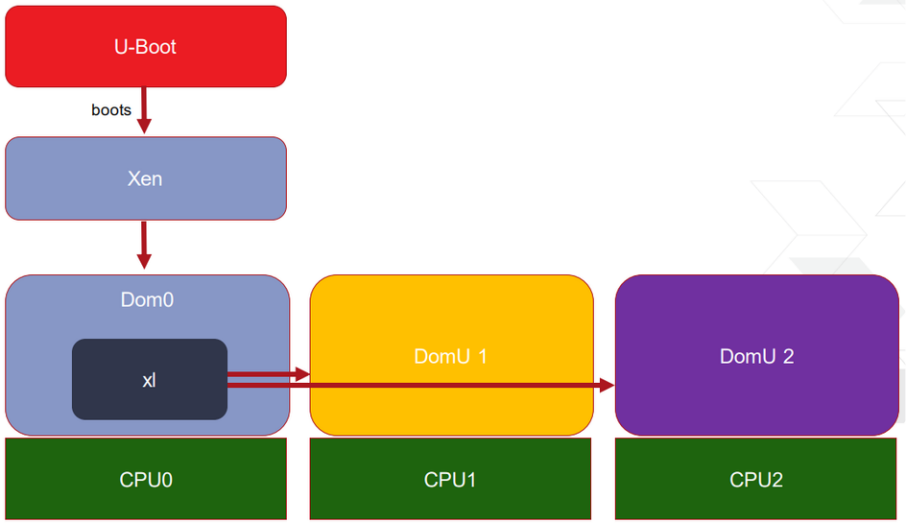
Paravirtualization

**Type II hypervisors**

VirtualBox

**Type I hypervisors (bare-metal hypervisors)**

XEN Hypervisor



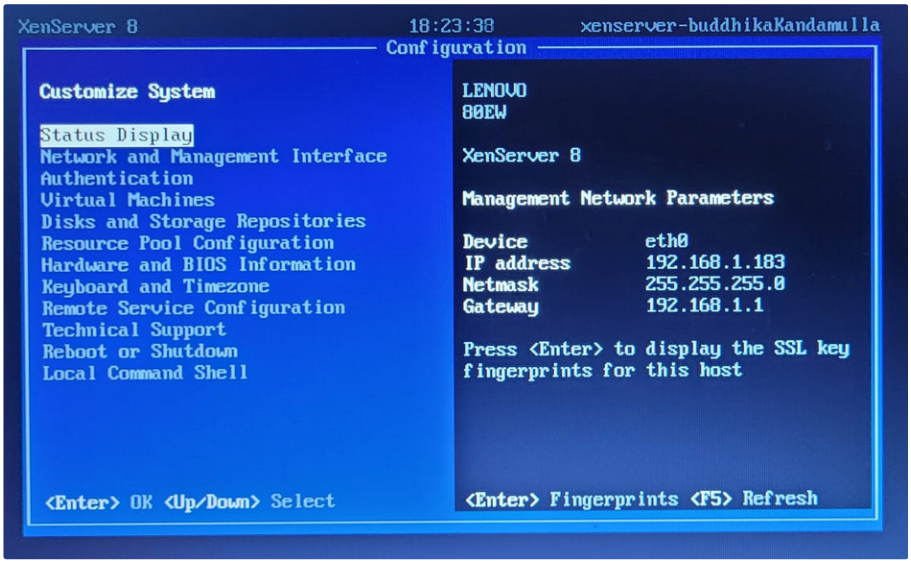

XPDDS19 Keynote: Xen Dom0-less - Stefano Stabellini, Principal Engineer, Xilinx

## Demo - Xen Hypervisor

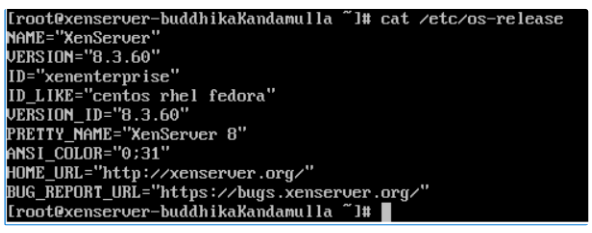
Xen Project Software Overview - Xen

**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

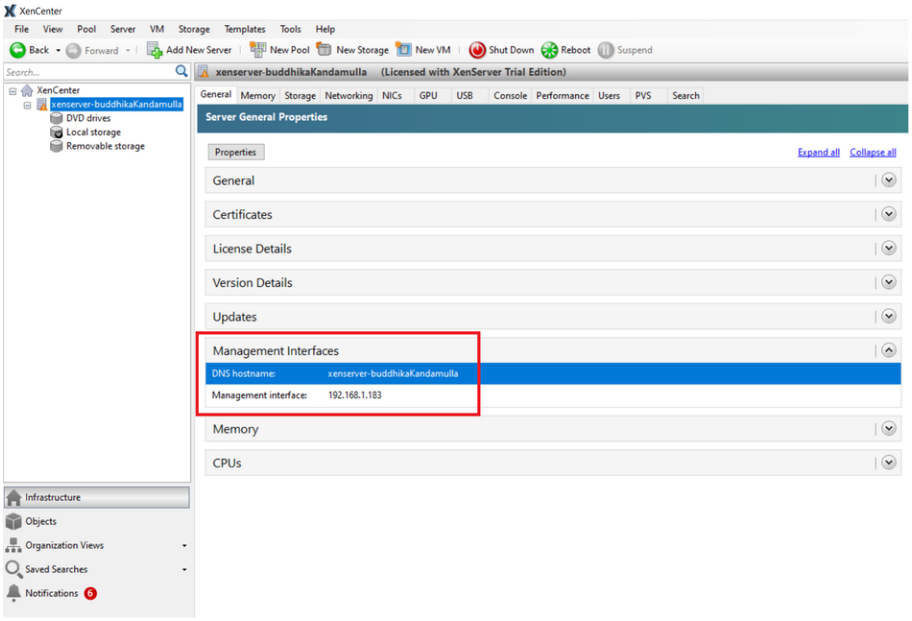



XenServer User Interface




DOM0 OS version of XenServer

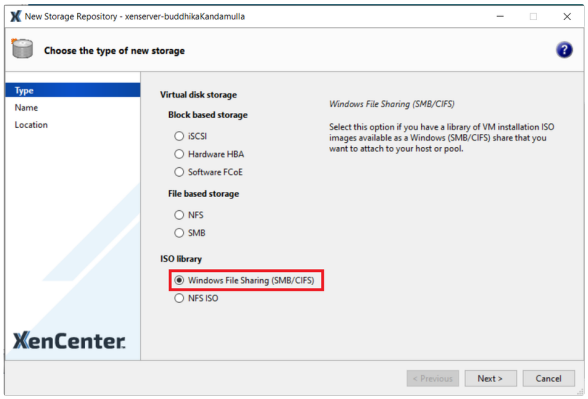
**Step2: XenCenter 2023.3.1 installation on user laptop and add server**




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

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

`ssh` into the XenServer and verify

```
bdy@bdy:~$ ssh root@192.168.1.183

[root@xenserver-buddhikaKandamulla ~]# ls -al /media/cdrom/
-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:

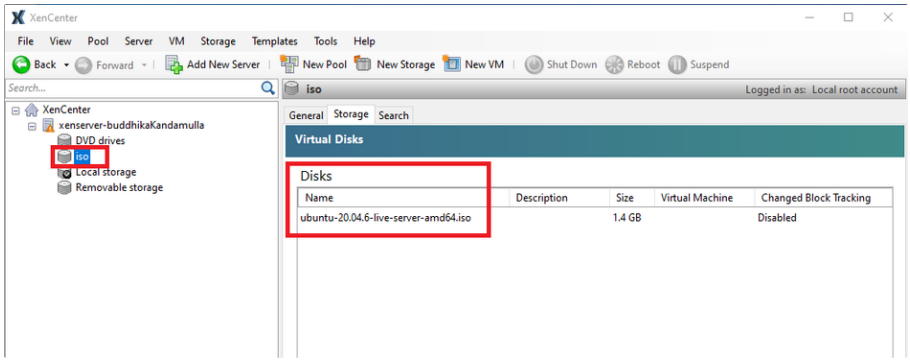
```
[root@xenserver-buddhikaKandamulla cdrom]# xe sr-create name-label="iso" type=iso device-config:location=/media/cdrom device-config
4521de1b-eb47-c9ca-df43-81da049ee49e
```

List Storage Repositories in the XenServer:

```
[root@xenserver-buddhikaKandamulla cdrom]# xe sr-list
...
uuid ( RO)                : 4521de1b-eb47-c9ca-df43-81da049ee49e
          name-label ( RW): iso
    name-description ( RW):
                host ( RO): xenserver-buddhikaKandamulla
```

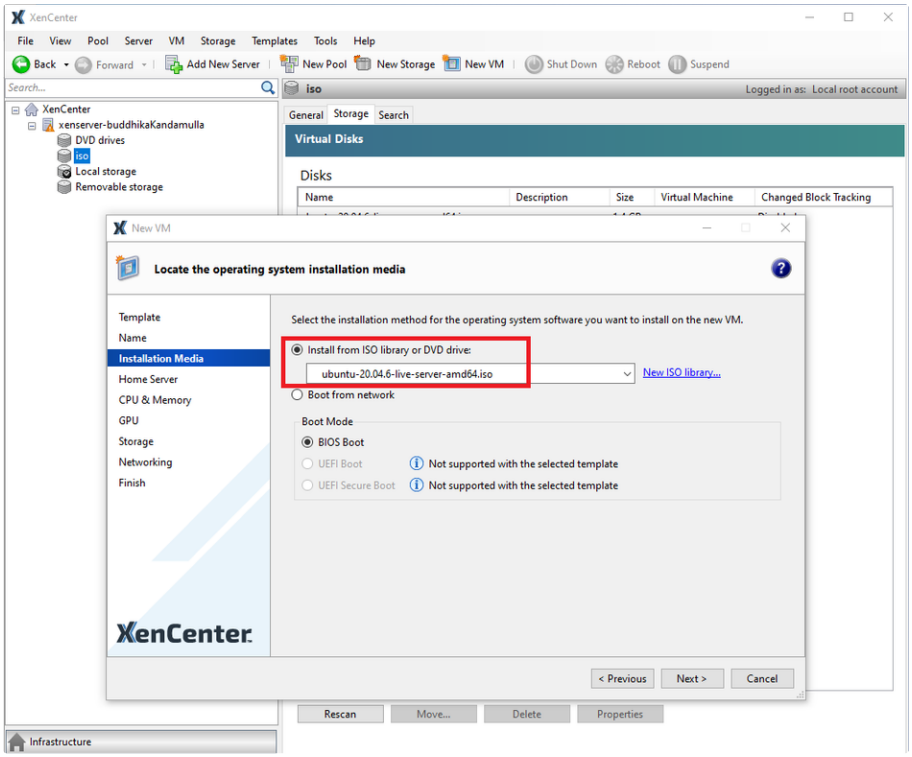
```
                type ( RO): iso
        content-type ( RO): iso
```

ISO Image Storage Repository XenCenter:



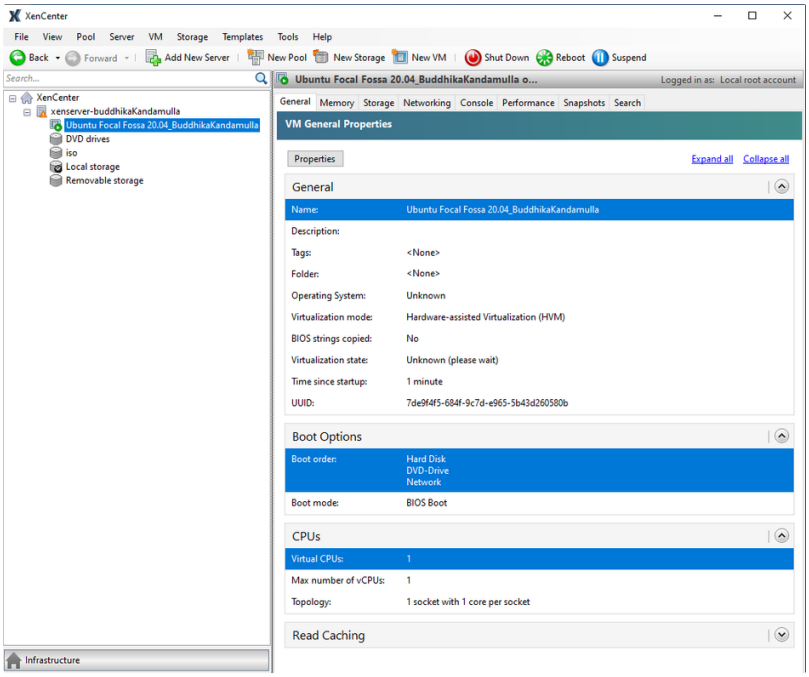

ISO Image Storage Repository mount

**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**

```
bdy@xenvmdebian3-buddhika:~$ cd benchmark_test/

# Get the installation package
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

bdy@xenvmdebian3-buddhika:~/benchmark_test$ ls
phoronix-test-suite_10.8.4_all.deb
```

**Installing Phoronix Test Suite**

```
# Install Phoronix Test Suite
$ sudo dpkg -i phoronix-test-suite_10.8.4_all.deb

# Install missing dependencies if necessary
$ sudo apt --fix-broken install
```

**Tests to be installed in next steps:**

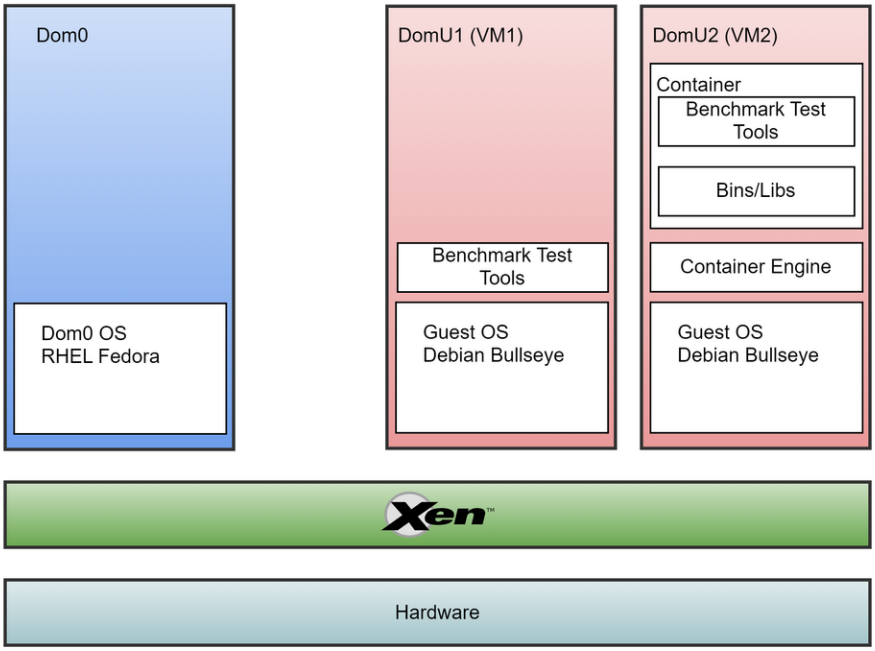
| Hardware component | Benchmark Test from `Phoronix Test Suite` |
|---|---|
| Processor | `N-Queens` |
| Memory | `RAMspeed SMP` |
| Disk | `Dbench` |

**Step 7: Create base snapshot**

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

VM1 - benchmark tests on VM

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




**Step 8: VM1 - benchmark tests on VM**

**Create VM from base snapshot**

**Benchmarking**

N-Queens

```
bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite install pts/n-queens

bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite run pts/n-queens-1.2.1
...
N-Queens 1.0:
    pts/n-queens-1.2.1
    Test 1 of 1
    Estimated Trial Run Count:    3
    Estimated Time To Completion: 36 Minutes [23:56 EEST]
        Started Run 1 @ 23:21:05
        Started Run 2 @ 23:26:59
        Started Run 3 @ 23:32:52

    Elapsed Time:
        349.545
        349.602
        349.483

    Average: 349.543 Seconds
    Deviation: 0.02%

    N-Queens 1.0
    Elapsed Time
    Seconds < Lower Is Better
    N-Queens_24Sept23 . 349.54
```

RAMspeed SMP

```
bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite install pts/ramspeed-1.4.3

bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite run pts/ramspeed-1.4.3
...
RAMspeed SMP 3.5.0:
    pts/ramspeed-1.4.3
    Memory Test Configuration
        1: Copy
        2: Scale
        3: Add
```

```
        4: Triad
        5: Average
        6: Test All Options
        ** Multiple items can be selected, delimit by a comma. **
        Type: 1,3

        1: Integer
        2: Floating Point
        3: Test All Options
        ** Multiple items can be selected, delimit by a comma. **
        Benchmark: 2

RAMspeed SMP 3.5.0:
    pts/ramspeed-1.4.3 [Type: Add - Benchmark: Floating Point]
    Test 1 of 2
    Estimated Trial Run Count:    3
    Estimated Test Run-Time:      6 Minutes
    Estimated Time To Completion: 12 Minutes [00:00 EEST]
        Started Run 1 @ 23:48:57
        Started Run 2 @ 23:52:43
        Started Run 3 @ 23:56:27

    Type: Add - Benchmark: Floating Point:
        8161.03
        8157.81
        8156.16

    Average: 8158.33 MB/s
    Deviation: 0.03%

RAMspeed SMP 3.5.0:
    pts/ramspeed-1.4.3 [Type: Copy - Benchmark: Floating Point]
    Test 2 of 2
    Estimated Trial Run Count:    3
    Estimated Time To Completion: 12 Minutes [00:11 EEST]
        Started Run 1 @ 00:00:20
        Started Run 2 @ 00:04:05
        Started Run 3 @ 00:07:50

    Type: Copy - Benchmark: Floating Point:
        7418.64
        7398.55
        7401.9

    Average: 7406.36 MB/s
    Deviation: 0.15%

    RAMspeed SMP 3.5.0
    Type: Add - Benchmark: Floating Point
    MB/s > Higher Is Better
    RAMspeed-SMP Test . 8158.33

    RAMspeed SMP 3.5.0
    Type: Copy - Benchmark: Floating Point
    MB/s > Higher Is Better
    RAMspeed-SMP Test . 7406.36
```

Dbench

```
bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite install pts/dbench

bdy@xenvmdebian3-buddhika:~$ phoronix-test-suite run pts/dbench-1.0.2
...
Dbench 4.0:
    pts/dbench-1.0.2
    Disk Test Configuration
        1: 1
        2: 6
        3: 12
        4: 48
        5: 128
        6: 256
        7: Test All Options
        ** Multiple items can be selected, delimit by a comma. **
        Client Count: 2,4

Dbench 4.0:
    pts/dbench-1.0.2 [Client Count: 6]
    Test 1 of 2
    Estimated Trial Run Count:    3
    Estimated Test Run-Time:      45 Minutes
    Estimated Time To Completion: 2 Hours, 15 Minutes [02:43 EEST]
        Started Run 1 @ 00:28:32
```

```
        Started Run 2 @ 00:40:36
        Started Run 3 @ 00:52:41

    Client Count: 6:
        255.977
        257.834
        267.091

    Average: 260.301 MB/s
    Deviation: 2.29%

Dbench 4.0:
    pts/dbench-1.0.2 [Client Count: 48]
    Test 2 of 2
    Estimated Trial Run Count:    3
    Estimated Test Run-Time:      37 Minutes
    Estimated Time To Completion: 1 Hour, 13 Minutes [02:16 EEST]
        Started Run 1 @ 01:04:52
        Started Run 2 @ 01:16:58
        Started Run 3 @ 01:29:04

    Client Count: 48:
        52.143
        52.385
        53.8318

    Average: 52.7866 MB/s
    Deviation: 1.73%

    Dbench 4.0
    Client Count: 6
    MB/s > Higher Is Better
    dbench disk benchmark test on XenVM . 260.30

    Dbench 4.0
    Client Count: 48
    MB/s > Higher Is Better
    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**

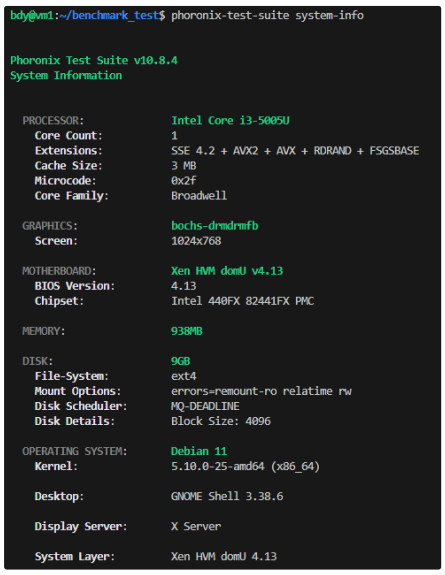
VM to run docker container has increased hardware allocation compared to previous VM. When Docker container with hardware limitations similar to previous VM

**Expand the partition and filesystem**

```
#Use PARTition EDitor utility to expand the partition
sudo parted /dev/xvda
    resizepart
    quit

#Resize the filesystem
sudo resize2fs /dev/xvda1
```

```
bdy@vm2:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/xvda1      8.9G  6.0G  2.5G  72% /

bdy@vm2:~$ lsblk
NAME    MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
xvda    202:0    0   20G  0 disk
├─xvda1 202:1    0    9G  0 part /
├─xvda2 202:2    0    1K  0 part
└─xvda5 202:5    0  975M  0 part [SWAP]

bdy@vm2:~$ sudo parted /dev/xvda
GNU Parted 3.4
Using /dev/xvda

(parted) print

Number  Start   End     Size    Type      File system     Flags
 1      1049kB  9713MB  9712MB  primary   ext4
 2      9714MB  10.7GB  1022MB  extended
 5      9714MB  10.7GB  1022MB  logical   linux-swap(v1)

(parted) rm 2

(parted) rm 5

(parted) resizepart 1 18GB

```

```
(parted) print
Number  Start   End     Size    Type     File system  Flags
 1      1049kB  18.0GB  18.0GB  primary  ext4

(parted) quit

bdy@vm2:~$ lsblk
NAME    MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sr0      11:0    1  389M  0 rom
xvda    202:0    0   20G  0 disk
└─xvda1 202:1    0 16.8G  0 part /

bdy@vm2:~$ sudo resize2fs /dev/xvda1
[sudo] password for bdy:
resize2fs 1.46.2 (28-Feb-2021)
Filesystem at /dev/xvda1 is mounted on /; on-line resizing required
old_desc_blocks = 2, new_desc_blocks = 3
The filesystem on /dev/xvda1 is now 4394275 (4k) blocks long.

bdy@vm2:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/xvda1       17G  6.0G  9.7G  38% /
```

| VM1 - benchmark tests on VM | VM2 - benchmark tests on Docker container running on top of VM |
|---|---|
|  |  |





#### Pull docker image of same OS version

```
bdy@vm2:~$ sudo docker pull debian:bullseye

bdy@vm2:~$ sudo docker images
REPOSITORY     TAG        IMAGE ID       CREATED         SIZE
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

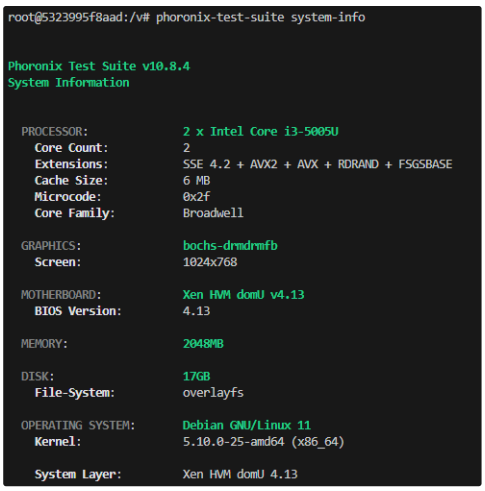
```
#Set Maximum Memory Access and CPU Usage
bdy@vm2:~/benchmark_test$ sudo docker run -it --name=debian_xen \
>   --volume ~/benchmark_test:/v \
>   --cpus="1.0" \
>   --memory="1g" \
>   debian:bullseye
root@5323995f8aad:/v#
```

#### Installing Phoronix Test Suite in the container

```
root@5323995f8aad:/v# apt-get update

root@5323995f8aad:/v# apt-get upgrade

root@5323995f8aad:/v# apt --fix-broken install
```

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

**Docker container with installed Phoronix Test Suite v10.8.4**




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

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

**Benchmarking**

N-Queens

```
 root@5323995f8aad:/v# phoronix-test-suite run pts/n-queens-1.2.1
N-Queens 1.0:
    pts/n-queens-1.2.1
    Test 1 of 1
    Estimated Trial Run Count:    3
    Estimated Time To Completion: 23 Minutes [14:20 UTC]
        Started Run 1 @ 13:58:11
        Started Run 2 @ 14:05:47
        Started Run 3 @ 14:13:14

    Elapsed Time:
        451.522
        443.628
        442.262

    Average: 445.804 Seconds
    Deviation: 1.12%

    N-Queens 1.0
    Elapsed Time
    Seconds < Lower Is Better
    NQueen-VM2 . 445.80
```

RAMspeed SMP

```
root@5323995f8aad:/v# phoronix-test-suite run pts/ramspeed-1.4.3

RAMspeed SMP 3.5.0:
    pts/ramspeed-1.4.3
    Memory Test Configuration
        1: Copy
        2: Scale
        3: Add
        4: Triad
        5: Average
        6: Test All Options
        ** Multiple items can be selected, delimit by a comma. **
        Type: 1,3

        1: Integer
        2: Floating Point
        3: Test All Options
        ** Multiple items can be selected, delimit by a comma. **
        Benchmark: 2

```

```
RAMspeed SMP 3.5.0:
    pts/ramspeed-1.4.3 [Type: Add - Benchmark: Floating Point]
    Test 1 of 2
    Estimated Trial Run Count:    3
    Estimated Test Run-Time:      6 Minutes
    Estimated Time To Completion: 12 Minutes [14:45 UTC]
        Started Run 1 @ 14:33:22
        Started Run 2 @ 14:38:34
        Started Run 3 @ 14:43:50

    Type: Add - Benchmark: Floating Point:
        5766.53
        5665.42
        5524.49

    Average: 5652.15 MB/s
    Deviation: 2.15%

RAMspeed SMP 3.5.0:
    pts/ramspeed-1.4.3 [Type: Copy - Benchmark: Floating Point]
    Test 2 of 2
    Estimated Trial Run Count:    3
    Estimated Time To Completion: 16 Minutes [15:05 UTC]
        Started Run 1 @ 14:49:21
        Started Run 2 @ 14:54:48
        Started Run 3 @ 15:00:13

    Type: Copy - Benchmark: Floating Point:
        5295.3
        5427.32
        5342.62

    Average: 5355.08 MB/s
    Deviation: 1.25%

    RAMspeed SMP 3.5.0
    Type: Add - Benchmark: Floating Point
    MB/s > Higher Is Better
    RAMspeed_VM2 . 5652.15

    RAMspeed SMP 3.5.0
    Type: Copy - Benchmark: Floating Point
    MB/s > Higher Is Better
    RAMspeed_VM2 . 5355.08
```

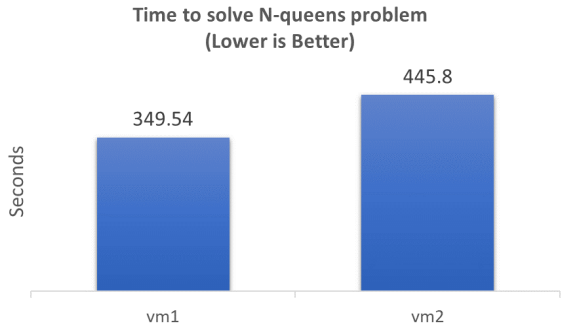
Dbench

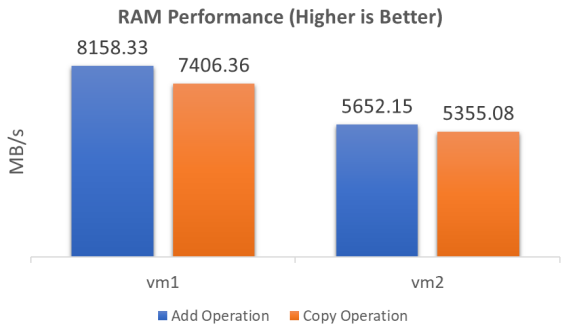
```
root@5323995f8aad:/v# phoronix-test-suite run pts/dbench-1.0.2
...
Dbench 4.0:
    pts/dbench-1.0.2
    Disk Test Configuration
        1: 1
        2: 6
        3: 12
        4: 48
        5: 128
        6: 256
        7: Test All Options
        ** Multiple items can be selected, delimit by a comma. **
        Client Count: 2,4

Dbench 4.0:
    pts/dbench-1.0.2 [Client Count: 6]
    Test 1 of 2
    Estimated Trial Run Count:    3
    Estimated Test Run-Time:      45 Minutes
    Estimated Time To Completion: 1 Hour, 30 Minutes [16:46 UTC]
        Started Run 1 @ 15:16:52
        Started Run 2 @ 15:28:57
        Started Run 3 @ 15:41:01

    Client Count: 6:
        170.2
        169.197
        168.236

    Average: 169.211 MB/s
    Deviation: 0.58%

Dbench 4.0:
    pts/dbench-1.0.2 [Client Count: 48]
    Test 2 of 2
```

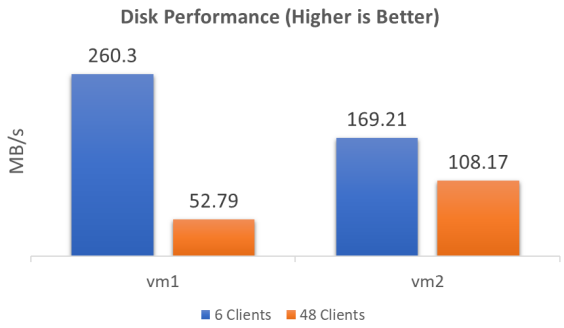
```
    Estimated Trial Run Count:    3
    Estimated Time To Completion: 37 Minutes [16:29 UTC]
        Started Run 1 @ 15:53:13
        Started Run 2 @ 16:05:19
        Started Run 3 @ 16:17:24

    Client Count: 48:
        105.816
        109.801
        108.894

    Average: 108.170 MB/s
    Deviation: 1.93%

    Dbench 4.0
    Client Count: 6
    MB/s > Higher Is Better
    Dbench_VM2 . 169.21
    Dbench 4.0
    Client Count: 48
    MB/s > Higher Is Better
    Dbench_VM2 . 108.17
```

**Step 10 - Test result comparison**

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



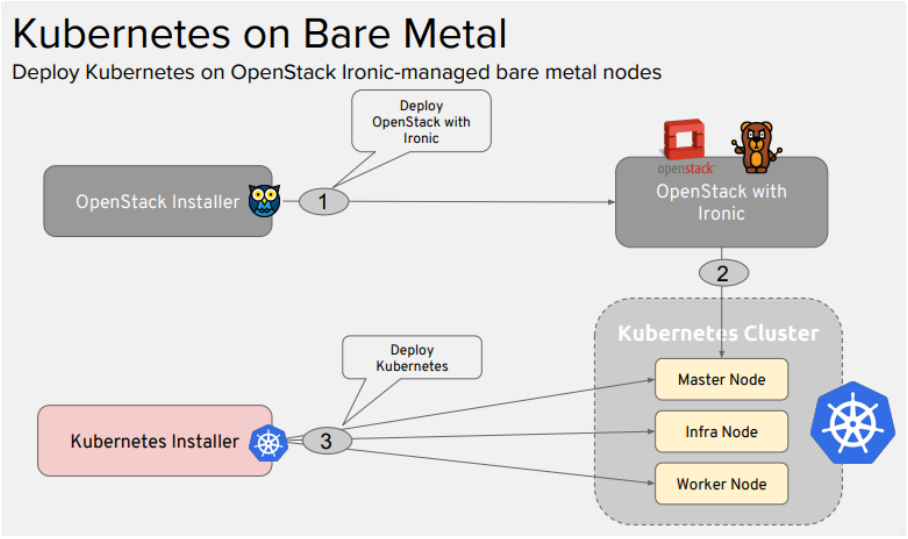



## Summery

<add>

## Future works

OpenStack Ironic




Kubernetes on OpenStack Ironic-managed bare metal nodes [ Open Infrastructure Summit videos from past community events, featuring keynotes and sessions from the global network of developers, operators, and supporting organizations. ]