Building GPU-enabled Kubernetes single node cluster for MLOps experiments with new+second hand components

1. **SUPERMICRO MBD-X11SAE-M-O Micro ATX Server Motherboard LGA 1151 Intel C236** from newegg.com - $200 (Link to Newegg)

2. **Intel Xeon E3-1275 V6 Kaby Lake 3.8 GHz (4.2 GHz Turbo) LGA 1151 Server Processor Intel HD Graphics P630** - $360 (Link to Newegg)

3. 64GB of RAM: four DIMMs of **16GB DDR4-2400 UDIMM 1.2V CL17 (SKU: CT16G4DFD824A)** from Crucial: $250 (Link to Crucial)

4. **Sabrent Rocket Q 1TB NVMe PCIe M.2 2280 Internal SSD High Performance Solid State Drive R/W 3200/2000MB/s (SB-RKTQ-1TB)**: $110 (Link to Amazon)

5. **Supermicro SNK-P0046A4 Heatsink 2U+ Active Heatsink LGA1156 & LGA1155**: $25 (Link to Supermicro store)

6. **Nvidia Tesla M40 12GB** (Second hand): $125(Link to Ebay)

7. Dual 8 to 8 Graphics Power Cable (SKU: 030-0571-000): $6 (Link to Ebay)

Really old components:

8. HDD and SSD: Western Digital HDD 250GB SATA3 6.0Gb/s 7.2K (Used): $0, SSD 120 GB SATA3 6.0 Gb/s 2.5” (Used): $0, SSD 120 GB SATA3 6.0 Gb/s 2.5” (Used): $0

9. SuperMicro Chassis 733I-500B with 500W PSU (Used): $0 (Link to SuperMicro)

Final configuration: 1 x Xeon E3-1275, 64GB RAM, 1.5TB storage with 1TB on NVMe, NVIDIA GPU (Maxwell architecture) with 12GB GDDR5 for **total: $1076.0 (Ouch!)**

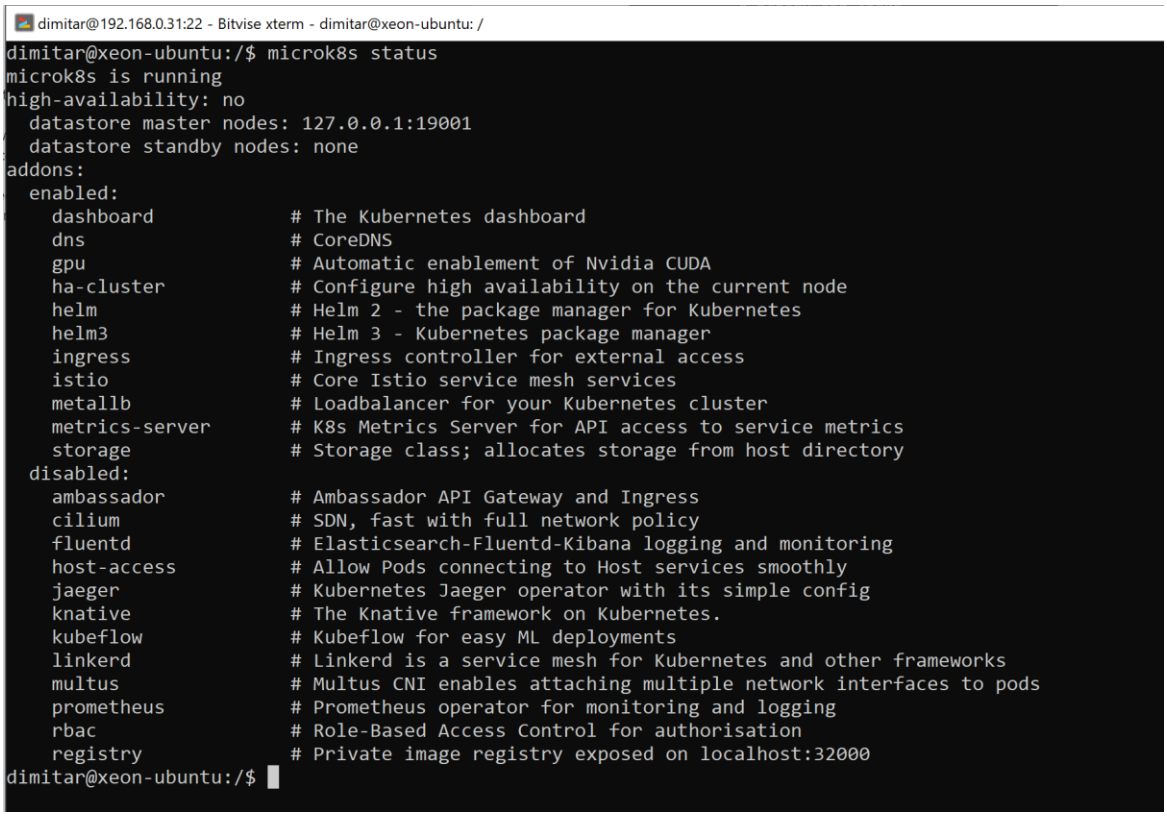
Additional Notes:

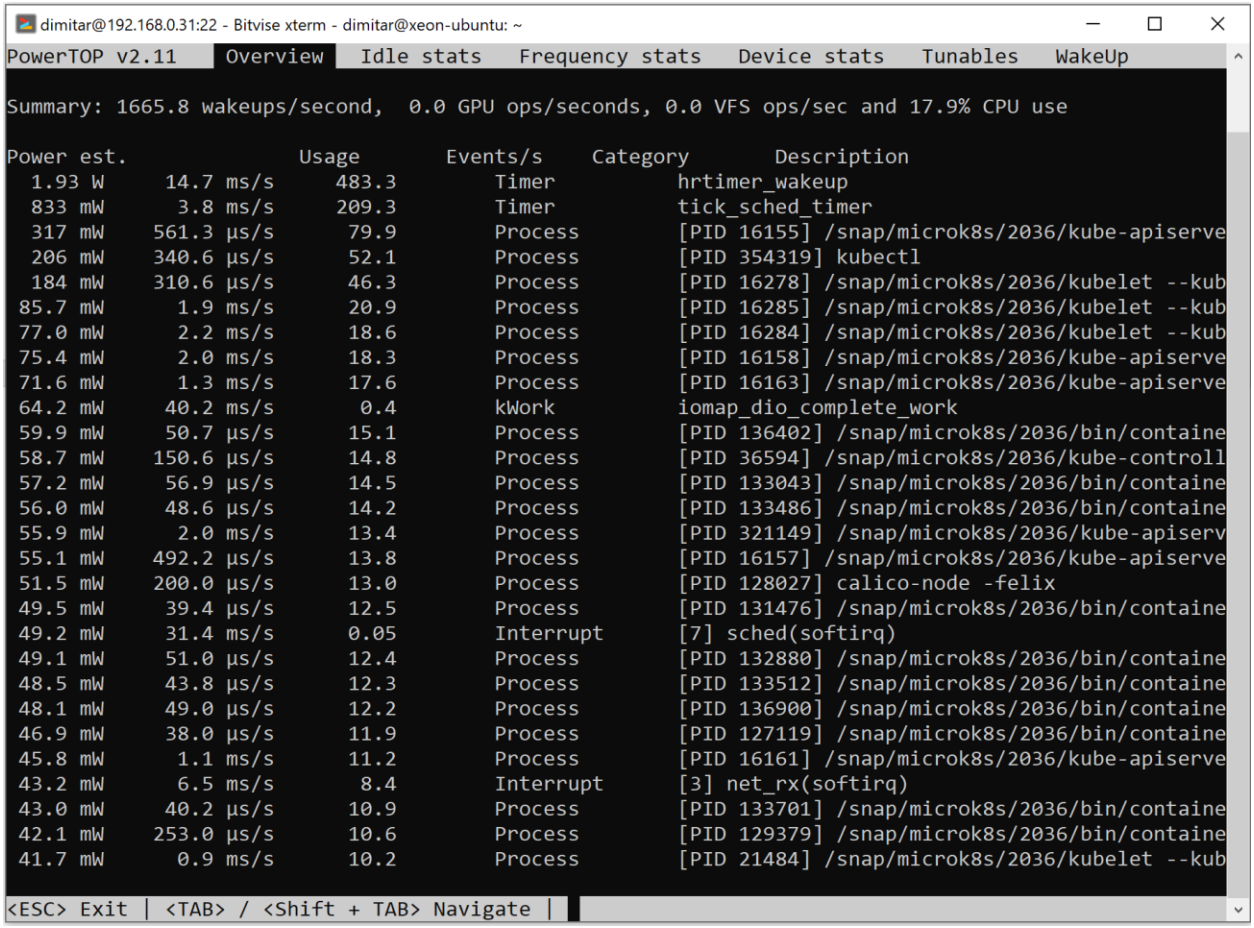
The 500W power supply coming with the mid tower chassis seems adequate for the graphics card provided you do not plan to reach frequently the max 250W which the card may need in peak memory and GPU utilization. The CPU drains no more than 73W, and the motherboard with the chipset and 64GB of RAM. Note that the chassis has an extension space allowing mounting larger power supply in case the one with 500W is not sufficient.

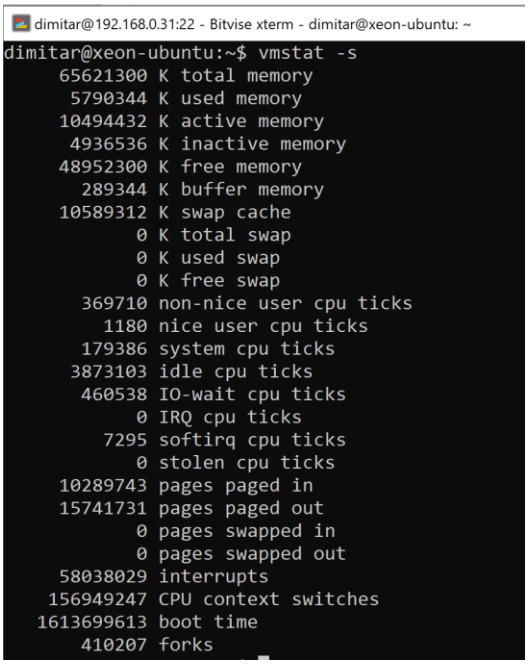
Use Ubuntu 20.04 and upgrade to 20.10.

Connect all disks (NVMe, SSD1, SSD2, and HDD) in a single file system using LVM2

Do not configure swap partition in case you are going to run Kubernetes locally using microk8s or minikube.


dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: /
dimitar@xeon-ubuntu:/$ microk8s status
microk8s is running
high-availability: no
  datastore master nodes: 127.0.0.1:19001
  datastore standby nodes: none
addons:
  enabled:
    dashboard   # The Kubernetes dashboard
    dns   # CoreDNS
    gpu   # Automatic enablement of Nvidia CUDA
    ha-cluster   # Configure high availability on the current node
    helm   # Helm 2 - the package manager for Kubernetes
    helm3   # Helm 3 - Kubernetes package manager
    ingress   # Ingress controller for external access
    istio   # Core Istio service mesh services
    metallb   # Loadbalancer for your Kubernetes cluster
    metrics-server   # K8s Metrics Server for API access to service metrics
    storage   # Storage class; allocates storage from host directory
  disabled:
    ambassador   # Ambassador API Gateway and Ingress
    cilium   # SDN, fast with full network policy
    fluentd   # Elasticsearch-Fluentd-Kibana logging and monitoring
    host-access   # Allow Pods connecting to Host services smoothly
    jaeger   # Kubernetes Jaeger operator with its simple config
    knative   # The Knative framework on Kubernetes.
    kubeflow   # Kubeflow for easy ML deployments
    linkerd   # Linkerd is a service mesh for Kubernetes and other frameworks
    multus   # Multus CNI enables attaching multiple network interfaces to pods
    prometheus   # Prometheus operator for monitoring and logging
    rbac   # Role-Based Access Control for authorisation
    registry   # Private image registry exposed on localhost:32000
dimitar@xeon-ubuntu:/$


dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: ~
PowerTOP v2.11 Overview Idle stats Frequency stats Device stats Tunables WakeUp
Summary: 1665.8 wakeups/second, 0.0 GPU ops/seconds, 0.0 VFS ops/sec and 17.9% CPU use
Power est. Usage Events/s Category Description
1.93 W 14.7 ms/s 483.3 Timer hrtimer_wakeup
833 mW 3.8 ms/s 209.3 Timer tick_sched_timer
317 mW 561.3 µs/s 79.9 Process [PID 16155] /snap/microk8s/2036/kube-apiserve
206 mW 340.6 µs/s 52.1 Process [PID 354319] kubectl
184 mW 310.6 µs/s 46.3 Process [PID 16278] /snap/microk8s/2036/kubelet --kub
85.7 mW 1.9 ms/s 20.9 Process [PID 16285] /snap/microk8s/2036/kubelet --kub
77.0 mW 2.2 ms/s 18.6 Process [PID 16284] /snap/microk8s/2036/kubelet --kub
75.4 mW 2.0 ms/s 18.3 Process [PID 16158] /snap/microk8s/2036/kube-apiserve
71.6 mW 1.3 ms/s 17.6 Process [PID 16163] /snap/microk8s/2036/kube-apiserve
64.2 mW 40.2 ms/s 0.4 kWork iomap_dio_complete_work
59.9 mW 50.7 µs/s 15.1 Process [PID 136402] /snap/microk8s/2036/bin/containe
58.7 mW 150.6 µs/s 14.8 Process [PID 36594] /snap/microk8s/2036/kube-controll
57.2 mW 56.9 µs/s 14.5 Process [PID 133043] /snap/microk8s/2036/bin/containe
56.0 mW 48.6 µs/s 14.2 Process [PID 133486] /snap/microk8s/2036/bin/containe
55.9 mW 2.0 ms/s 13.4 Process [PID 321149] /snap/microk8s/2036/kube-apiserv
55.1 mW 492.2 µs/s 13.8 Process [PID 16157] /snap/microk8s/2036/kube-apiserve
51.5 mW 200.0 µs/s 13.0 Process [PID 128027] calico-node -felix
49.5 mW 39.4 µs/s 12.5 Process [PID 131476] /snap/microk8s/2036/bin/containe
49.2 mW 31.4 ms/s 0.05 Interrupt [7] sched(softirq)
49.1 mW 51.0 µs/s 12.4 Process [PID 132880] /snap/microk8s/2036/bin/containe
48.5 mW 43.8 µs/s 12.3 Process [PID 133512] /snap/microk8s/2036/bin/containe
48.1 mW 49.0 µs/s 12.2 Process [PID 136900] /snap/microk8s/2036/bin/containe
46.9 mW 38.0 µs/s 11.9 Process [PID 127119] /snap/microk8s/2036/bin/containe
45.8 mW 1.1 ms/s 11.2 Process [PID 16161] /snap/microk8s/2036/kube-apiserve
43.2 mW 6.5 ms/s 8.4 Interrupt [3] net_rx(softirq)
43.0 mW 40.2 µs/s 10.9 Process [PID 133701] /snap/microk8s/2036/bin/containe
42.1 mW 253.0 µs/s 10.6 Process [PID 129379] /snap/microk8s/2036/bin/containe
41.7 mW 0.9 ms/s 10.2 Process [PID 21484] /snap/microk8s/2036/kubelet --kub
<ESC> Exit | <TAB> / <Shift + TAB> Navigate |


dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: ~
dimitar@xeon-ubuntu:~$ vmstat -s
65621300 K total memory
5790344 K used memory
10494432 K active memory
4936536 K inactive memory
48952300 K free memory
289344 K buffer memory
10589312 K swap cache
0 K total swap
0 K used swap
0 K free swap
369710 non-nice user cpu ticks
1180 nice user cpu ticks
179386 system cpu ticks
3873103 idle cpu ticks
460538 IO-wait cpu ticks
0 IRQ cpu ticks
7295 softirq cpu ticks
0 stolen cpu ticks
10289743 pages paged in
15741731 pages paged out
0 pages swapped in
0 pages swapped out
58038029 interrupts
156949247 CPU context switches
1613699613 boot time
410207 forks

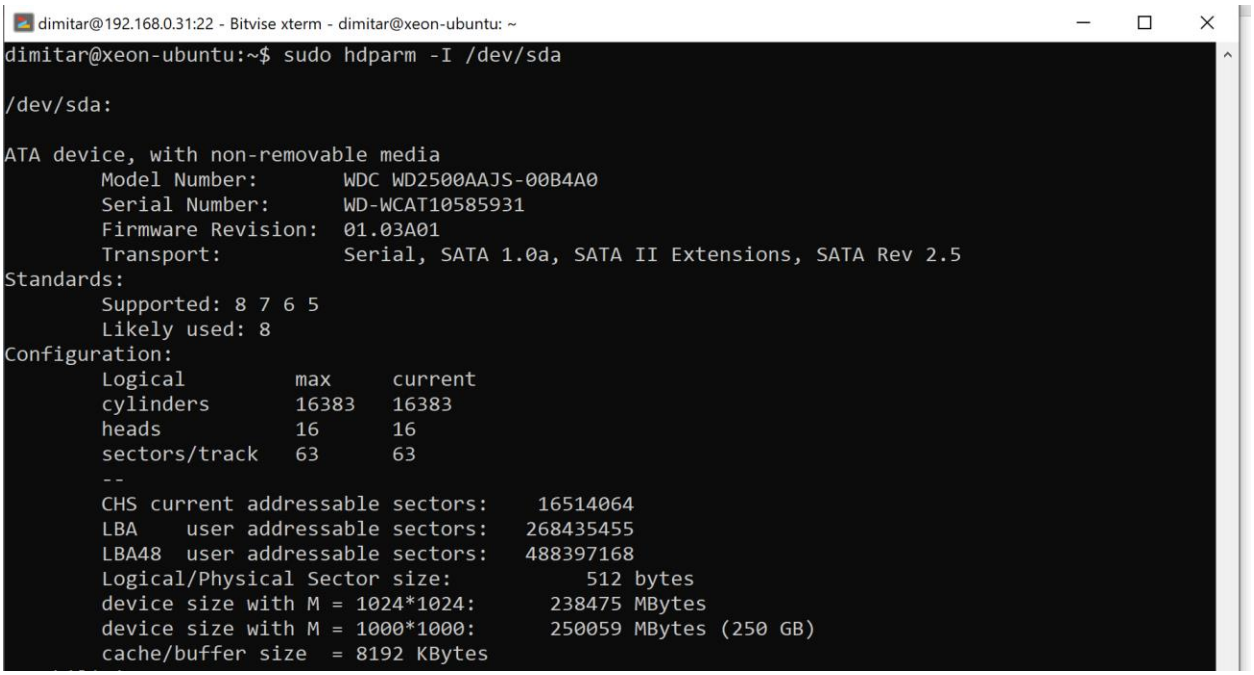
dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: /usr/local/cuda-11.2/samples/1_Utilities/deviceQuery

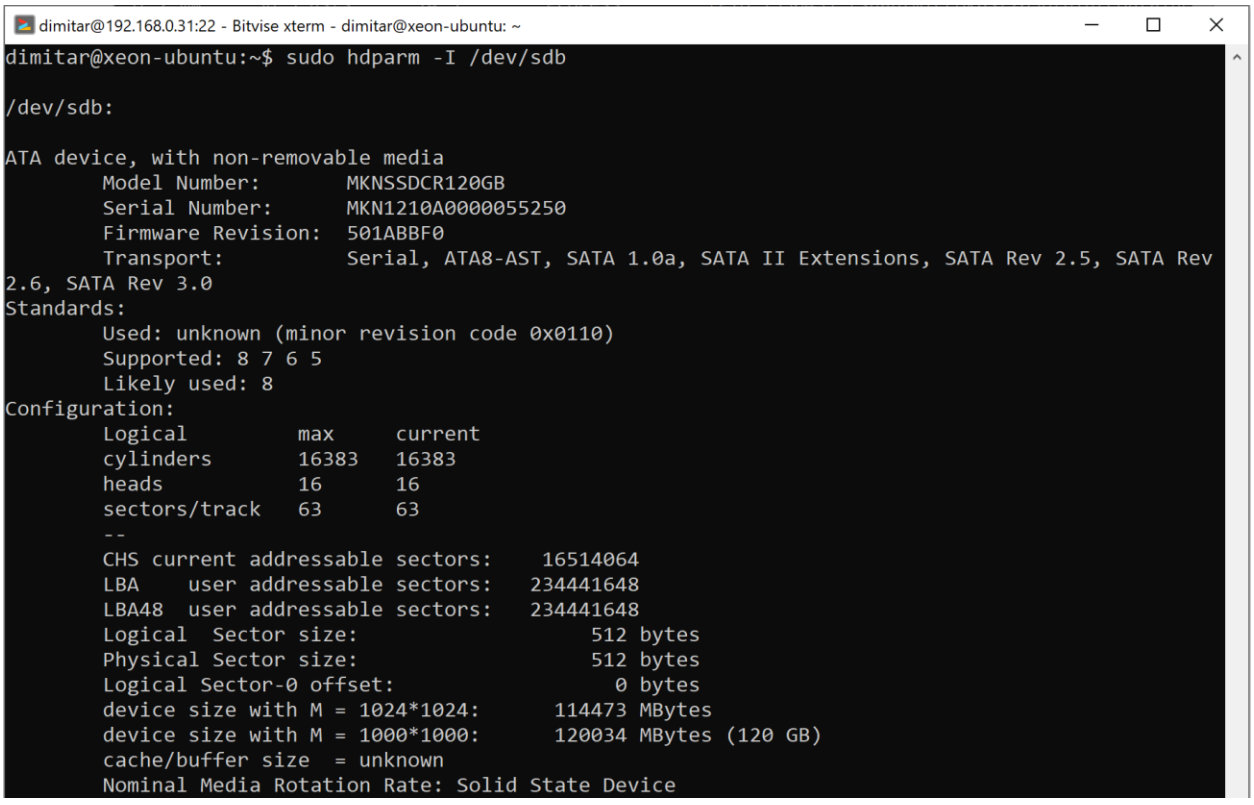
```
dimitar@xeon-ubuntu:/usr/local/cuda-11.2/samples/1_Utilities/deviceQuery$ ./deviceQuery
./deviceQuery Starting...

 CUDA Device Query (Runtime API) version (CUDART static linking)

Detected 1 CUDA Capable device(s)

Device 0: "Tesla M40"
  CUDA Driver Version / Runtime Version          11.2 / 11.2
  CUDA Capability Major/Minor version number:    5.2
  Total amount of global memory:                 11449 MBytes (12004753408 bytes)
  (24) Multiprocessors, (128) CUDA Cores/MP:     3072 CUDA Cores
  GPU Max Clock rate:                            1112 MHz (1.11 GHz)
  Memory Clock rate:                             3004 Mhz
  Memory Bus Width:                              384-bit
  L2 Cache Size:                                 3145728 bytes
  Maximum Texture Dimension Size (x,y,z)         1D=(65536), 2D=(65536, 65536), 3D=(4096, 4096, 4096)
  Maximum Layered 1D Texture Size, (num) layers  1D=(16384), 2048 layers
  Maximum Layered 2D Texture Size, (num) layers  2D=(16384, 16384), 2048 layers
  Total amount of constant memory:               65536 bytes
  Total amount of shared memory per block:       49152 bytes
  Total shared memory per multiprocessor:        98304 bytes
  Total number of registers available per block: 65536
  Warp size:                                     32
  Maximum number of threads per multiprocessor:  2048
  Maximum number of threads per block:           1024
  Max dimension size of a thread block (x,y,z): (1024, 1024, 64)
  Max dimension size of a grid size    (x,y,z): (2147483647, 65535, 65535)
  Maximum memory pitch:                          2147483647 bytes
  Texture alignment:                             512 bytes
  Concurrent copy and kernel execution:          Yes with 2 copy engine(s)
  Run time limit on kernels:                     Yes
  Integrated GPU sharing Host Memory:            No
  Support host page-locked memory mapping:       Yes
  Alignment requirement for Surfaces:            Yes
```

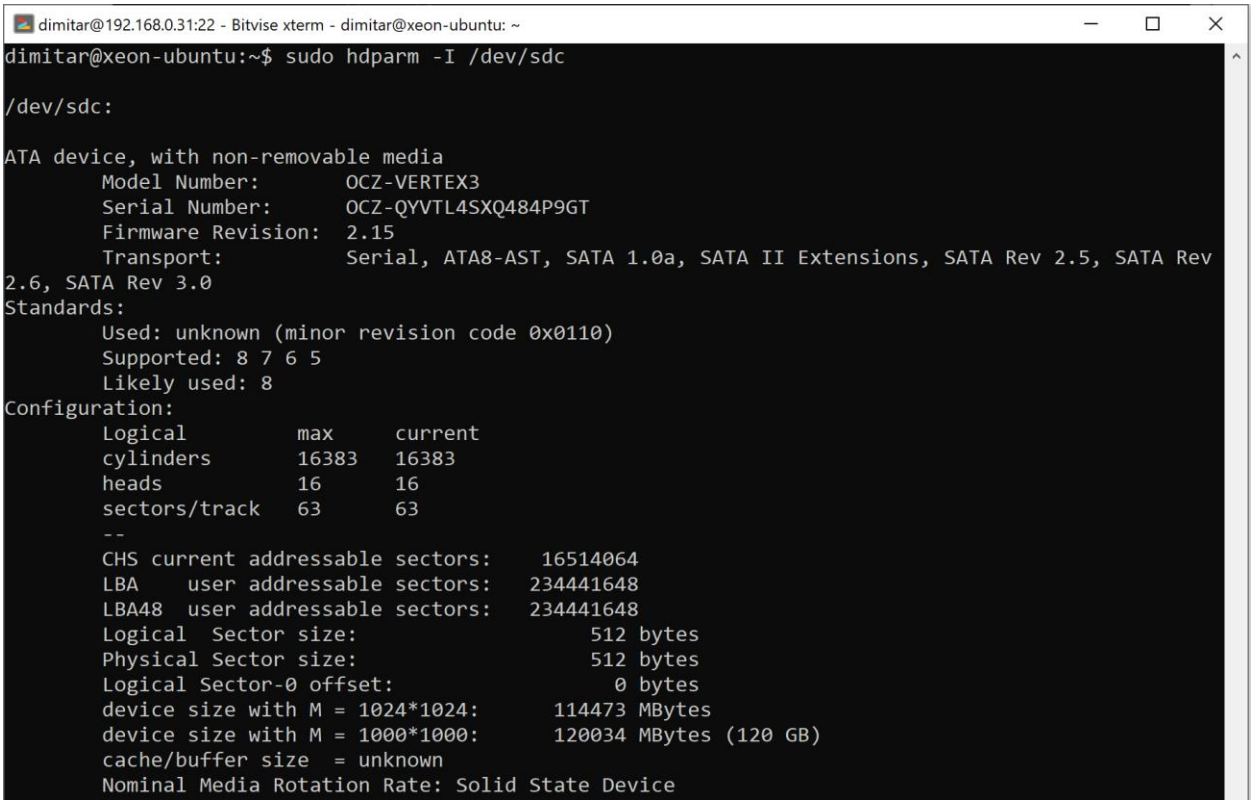
dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: /usr/local/cuda-11.2/samples/1_Utilities/bandwidthTest

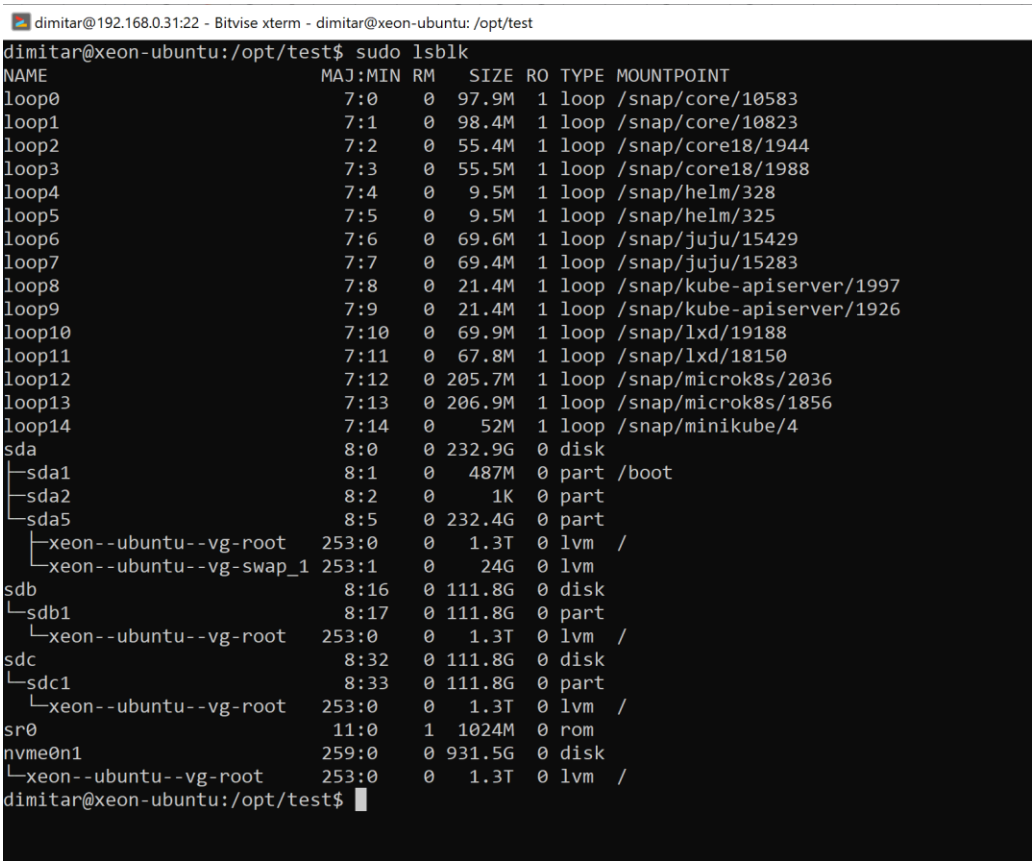
```
dimitar@xeon-ubuntu:/usr/local/cuda-11.2/samples/1_Utilities/bandwidthTest$ ./bandwidthTest
[CUDA Bandwidth Test] - Starting...
Running on...

 Device 0: Tesla M40
 Quick Mode

 Host to Device Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)        Bandwidth(GB/s)
   32000000                     12.2

 Device to Host Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)        Bandwidth(GB/s)
   32000000                     12.9

 Device to Device Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)        Bandwidth(GB/s)
   32000000                     216.8

Result = PASS

NOTE: The CUDA Samples are not meant for performance measurements. Results may vary when GPU Boost is enabled.
dimitar@xeon-ubuntu:/usr/local/cuda-11.2/samples/1_Utilities/bandwidthTest$
```

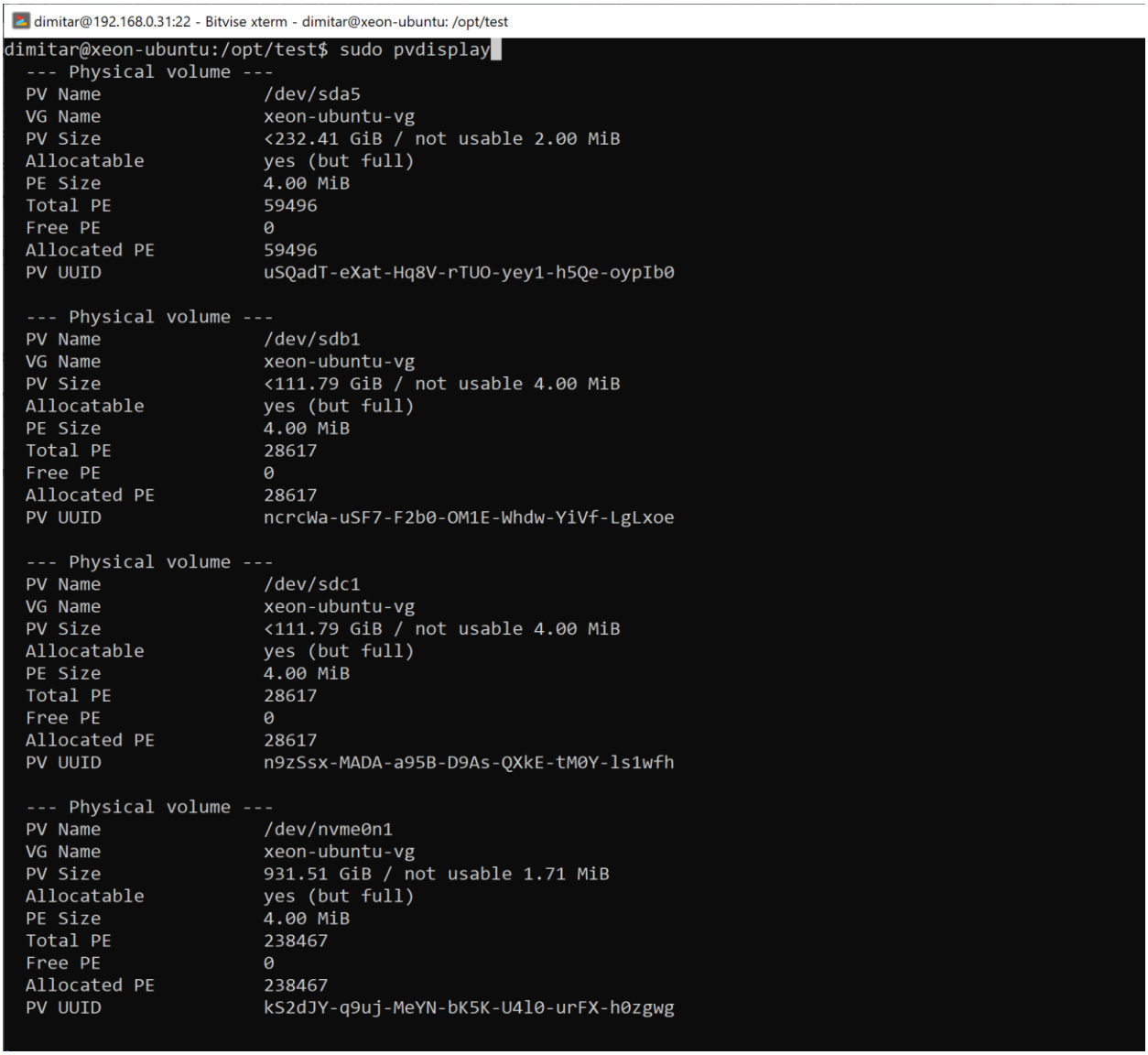
```
dimitar@xeon-ubuntu:~$ sudo nvme list
Node             SN                   Model                                    Namespace Usage                      Format           FW Rev
---------------- -------------------- ---------------------------------------- --------- -------------------------- ---------------- --------
/dev/nvme0n1     0546070A1EF388282021 Sabrent Rocket Q                         1           1.00  TB /   1.00  TB    512   B +  0 B   RKT30Q.2
dimitar@xeon-ubuntu:~$
```

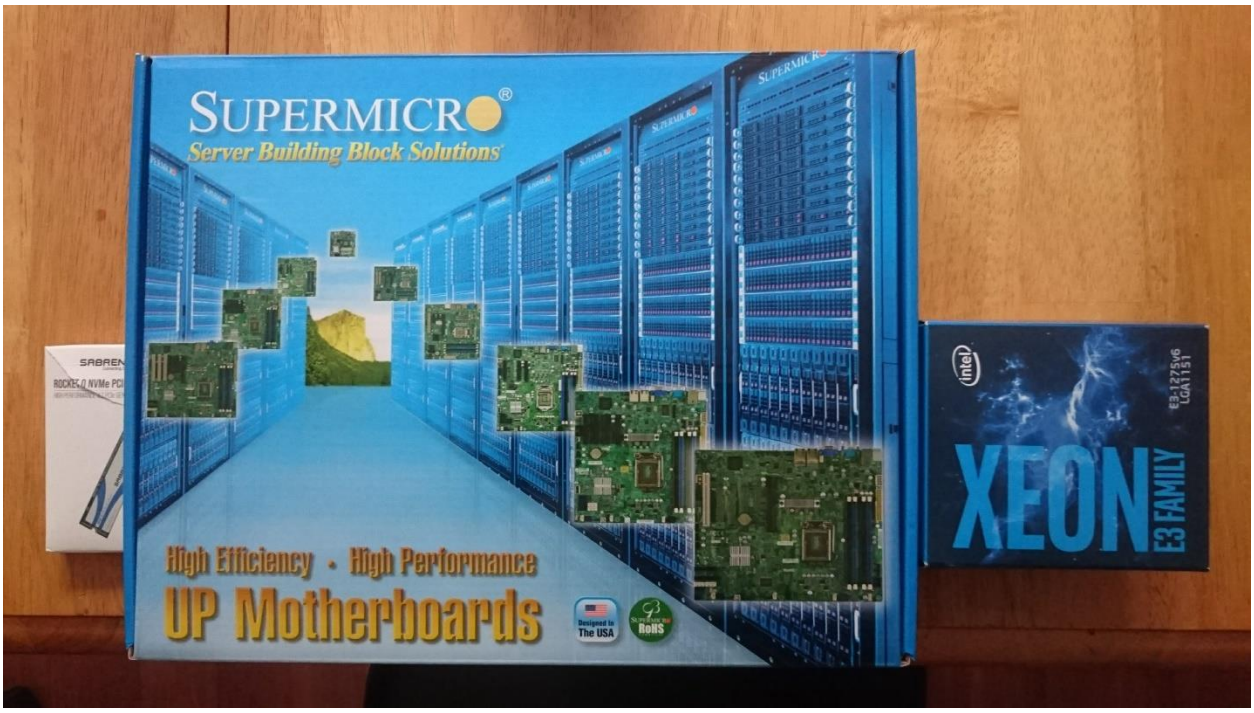

dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: ~
dimitar@xeon-ubuntu:~$ sudo hdparm -I /dev/sda
/dev/sda:
ATA device, with non-removable media
Model Number: WDC WD2500AAJS-00B4A0
Serial Number: WD-WCAT10585931
Firmware Revision: 01.03A01
Transport: Serial, SATA 1.0a, SATA II Extensions, SATA Rev 2.5
Standards:
Supported: 8 7 6 5
Likely used: 8
Configuration:
Logical max current
cylinders 16383 16383
heads 16 16
sectors/track 63 63
--
CHS current addressable sectors: 16514064
LBA user addressable sectors: 268435455
LBA48 user addressable sectors: 488397168
Logical/Physical Sector size: 512 bytes
device size with M = 1024*1024: 238475 MBytes
device size with M = 1000*1000: 250059 MBytes (250 GB)
cache/buffer size = 8192 KBytes

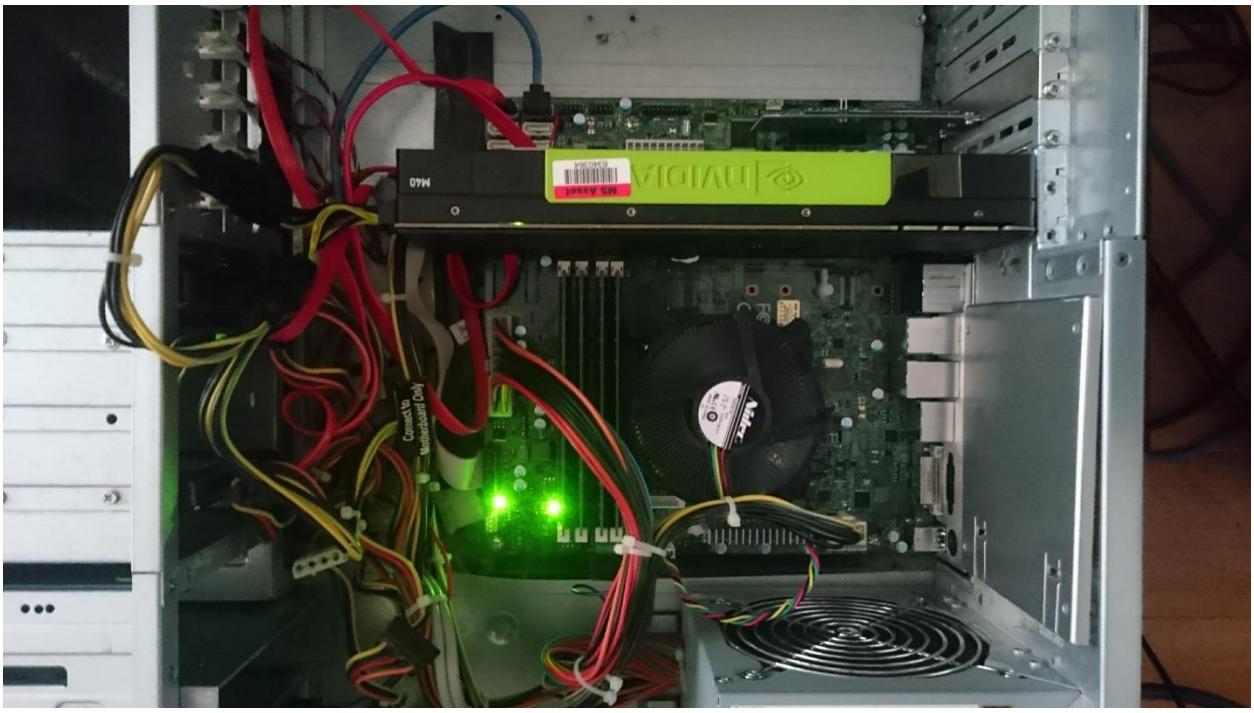

dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: ~
dimitar@xeon-ubuntu:~$ sudo hdparm -I /dev/sdb
/dev/sdb:
ATA device, with non-removable media
Model Number: MKNSSDCR120GB
Serial Number: MKN1210A0000055250
Firmware Revision: 501ABBF0
Transport: Serial, ATA8-AST, SATA 1.0a, SATA II Extensions, SATA Rev 2.5, SATA Rev 2.6, SATA Rev 3.0
Standards:
Used: unknown (minor revision code 0x0110)
Supported: 8 7 6 5
Likely used: 8
Configuration:
Logical max current
cylinders 16383 16383
heads 16 16
sectors/track 63 63
--
CHS current addressable sectors: 16514064
LBA user addressable sectors: 234441648
LBA48 user addressable sectors: 234441648
Logical Sector size: 512 bytes
Physical Sector size: 512 bytes
Logical Sector-0 offset: 0 bytes
device size with M = 1024*1024: 114473 MBytes
device size with M = 1000*1000: 120034 MBytes (120 GB)
cache/buffer size = unknown
Nominal Media Rotation Rate: Solid State Device


dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: ~
dimitar@xeon-ubuntu:~$ sudo hdparm -I /dev/sdc
/dev/sdc:
ATA device, with non-removable media
Model Number: OCZ-VERTEX3
Serial Number: OCZ-QYVTL4SXQ484P9GT
Firmware Revision: 2.15
Transport: Serial, ATA8-AST, SATA 1.0a, SATA II Extensions, SATA Rev 2.5, SATA Rev 2.6, SATA Rev 3.0
Standards:
Used: unknown (minor revision code 0x0110)
Supported: 8 7 6 5
Likely used: 8
Configuration:
Logical max current
cylinders 16383 16383
heads 16 16
sectors/track 63 63
--
CHS current addressable sectors: 16514064
LBA user addressable sectors: 234441648
LBA48 user addressable sectors: 234441648
Logical Sector size: 512 bytes
Physical Sector size: 512 bytes
Logical Sector-0 offset: 0 bytes
device size with M = 1024*1024: 114473 MBytes
device size with M = 1000*1000: 120034 MBytes (120 GB)
cache/buffer size = unknown
Nominal Media Rotation Rate: Solid State Device


dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: /opt/test
dimitar@xeon-ubuntu:/opt/test$ sudo lsblk
NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
loop0 7:0 0 97.9M 1 loop /snap/core/10583
loop1 7:1 0 98.4M 1 loop /snap/core/10823
loop2 7:2 0 55.4M 1 loop /snap/core18/1944
loop3 7:3 0 55.5M 1 loop /snap/core18/1988
loop4 7:4 0 9.5M 1 loop /snap/helm/328
loop5 7:5 0 9.5M 1 loop /snap/helm/325
loop6 7:6 0 69.6M 1 loop /snap/juju/15429
loop7 7:7 0 69.4M 1 loop /snap/juju/15283
loop8 7:8 0 21.4M 1 loop /snap/kube-apiserver/1997
loop9 7:9 0 21.4M 1 loop /snap/kube-apiserver/1926
loop10 7:10 0 69.9M 1 loop /snap/lxd/19188
loop11 7:11 0 67.8M 1 loop /snap/lxd/18150
loop12 7:12 0 205.7M 1 loop /snap/microk8s/2036
loop13 7:13 0 206.9M 1 loop /snap/microk8s/1856
loop14 7:14 0 52M 1 loop /snap/minikube/4
sda 8:0 0 232.9G 0 disk
├─sda1 8:1 0 487M 0 part /boot
├─sda2 8:2 0 1K 0 part
└─sda5 8:5 0 232.4G 0 part
├─xeon--ubuntu--vg-root 253:0 0 1.3T 0 lvm /
└─xeon--ubuntu--vg-swap_1 253:1 0 24G 0 lvm
sdb 8:16 0 111.8G 0 disk
└─sdb1 8:17 0 111.8G 0 part
└─xeon--ubuntu--vg-root 253:0 0 1.3T 0 lvm /
sdc 8:32 0 111.8G 0 disk
└─sdc1 8:33 0 111.8G 0 part
└─xeon--ubuntu--vg-root 253:0 0 1.3T 0 lvm /
sr0 11:0 1 1024M 0 rom
nvme0n1 259:0 0 931.5G 0 disk
└─xeon--ubuntu--vg-root 253:0 0 1.3T 0 lvm /
dimitar@xeon-ubuntu:/opt/test$


dimitar@192.168.0.31:22 - Bitvise xterm - dimitar@xeon-ubuntu: /opt/test
dimitar@xeon-ubuntu:/opt/test$ sudo pvdisplay
--- Physical volume ---
PV Name /dev/sda5
VG Name xeon-ubuntu-vg
PV Size <232.41 GiB / not usable 2.00 MiB
Allocatable yes (but full)
PE Size 4.00 MiB
Total PE 59496
Free PE 0
Allocated PE 59496
PV UUID uSQadT-eXat-Hq8V-rTUO-yey1-h5Qe-oypIb0
--- Physical volume ---
PV Name /dev/sdb1
VG Name xeon-ubuntu-vg
PV Size <111.79 GiB / not usable 4.00 MiB
Allocatable yes (but full)
PE Size 4.00 MiB
Total PE 28617
Free PE 0
Allocated PE 28617
PV UUID ncrcWa-uSF7-F2b0-OM1E-Whdw-YiVf-LgLxoe
--- Physical volume ---
PV Name /dev/sdc1
VG Name xeon-ubuntu-vg
PV Size <111.79 GiB / not usable 4.00 MiB
Allocatable yes (but full)
PE Size 4.00 MiB
Total PE 28617
Free PE 0
Allocated PE 28617
PV UUID n9zSsx-MADA-a95B-D9As-QXkE-tM0Y-ls1wfh
--- Physical volume ---
PV Name /dev/nvme0n1
VG Name xeon-ubuntu-vg
PV Size 931.51 GiB / not usable 1.71 MiB
Allocatable yes (but full)
PE Size 4.00 MiB
Total PE 238467
Free PE 0
Allocated PE 238467
PV UUID kS2dJY-q9uj-MeYN-bK5K-U4l0-urFX-h0zgwg


SUPERMICRO
Server Building Block Solutions
High Efficiency • High Performance
UP Motherboards
Designed in The USA
RoHS
intel
XEON
E3 FAMILY


NVIDIA
M40
Connect to
Motherboard Only