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@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:/$
```

```
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@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@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@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@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@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
```