Kubernetes and GPUs

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Hardware

Some older cards: Nvidia K20s, AMD Vega

Mostly focusing on Nvidia enterprise cards: P100, V100, T4

Started looking at use cases for each type of card

- V100s show better performance
- T4s have less cores but lower power consumption (70W), passive cooling

Integrating GPUs

Baremetal is straightforward

For virtual machines there are two possibilities

- PCI Passthrough: full device exposed and dedicated to one virtual machine
- vGPUs: *partitions* of the GPU exposed to the virtual machine

At CERN we currently offer baremetal and PCI passthrough

Ongoing work for Nvidia vGPUs

Use cases for all three possible setups

OpenStack Integration

Our cloud infrastructure relies on OpenStack

Support status for the different modes

	Scheduling	Quotas	Monitoring	Sharing	NUMA	Performance	License
Baremetal	Flavors	No	No	No	Yes	Best	x
PCI Passthrough	Flavors	No	No	No	Yes	Best	x
vGPU	Yes	Ongoing	Possible	Yes	No	< 10% loss?	vComputeServer *

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Nvidia
~$50 / year
up to 8 VMs / GPU

OpenStack Integration

vGPUs seem like the easiest path to get GPUs as first class resources

- Required integration almost finished for proper scheduling and quotas
- Won’t work for other type of resources, FPGAs, …

We plan to add this mode to our offering very soon

Kubernetes Integration

Relying on *node groups/pools* to get heterogeneous clusters

Different flavor for each node group: m2.xlarge, g1.xlarge, ...

Automated detection and configuration of GPUs

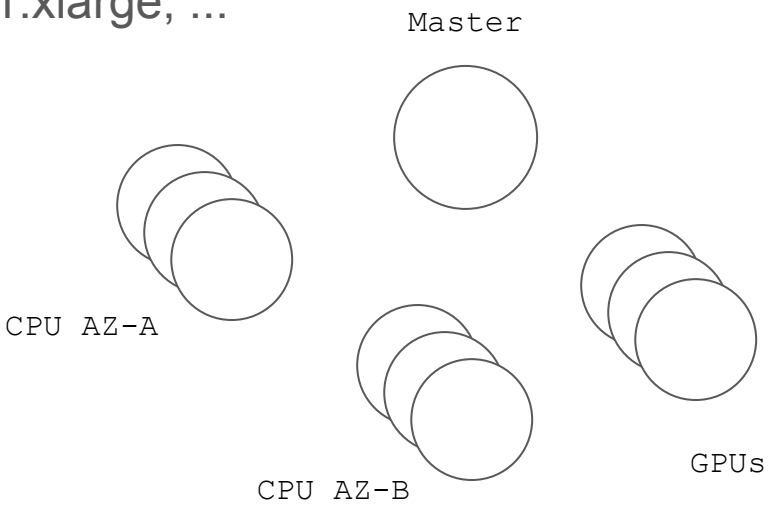
- Managed by a Helm chart

  https://gitlab.cern.ch/helm/charts/cern/tree/master/nvidia-gpu

- Alternative with the GPU operator

  https://github.com/NVIDIA/gpu-operator

https://github.com/NVIDIA/k8s-device-plugin



Kubernetes Integration

GPUs are already treated as first class resources in Kubernetes

Scheduling	Quotas	Monitoring	Sharing	NUMA	Performance	License
Yes	Yes	Yes	No	Yes	Best	x

```
apiVersion: v1
kind: Pod
metadata:
  name: mypod
spec:
  containers:
    - name: mycontainer
      image: "mycontainerimage:tag"
      resources:
        limits:
          nvidia.com/gpu: 1 # no fractions possible
```

```
$ kubectl get nodes
NAME                          STATUS   ROLES    AGE   VERSION
...
hub-001-gpu-nvi...7iz-node-0  Ready    gpu      63d   v1.15.3
hub-001-gpu-nvi...7iz-node-1  Ready    gpu      63d   v1.15.3
```

Kubernetes Integration

Monitoring is done with a Nvidia Prometheus exporter

Metrics for temperature, SM/Memory clocks, power usage, throughput, ...

https://github.com/NVIDIA/gpu-monitoring-tools/

Next Steps

Evaluate performance penalty of using vGPUs

- Likely to keep offering both PCI passthrough and vGPUs
- Explore the Kubernetes TopologyManager for NUMA affinity

Try out SR-IOV for GPU virtualization of non Nvidia vendors

No concrete requests for accelerators other than GPUs on Kubernetes yet

- Occasional requests to integrate special devices (tape drives, USB dongles)

Backup

Ongoing Work - OpenStack

Quota integration for vGPUs in OpenStack Nova using unified limits, placement

https://blueprints.launchpad.net/nova/+spec/count-quota-usage-from-placement

https://specs.openstack.org/openstack/nova-specs/specs/ussuri/approved/unified-limits-nova.html

Missing NUMA topology knowledge when scheduling vGPUs

https://bugzilla.redhat.com/show_bug.cgi?id=1553832

Performance penalty when CPU/GPU in different NUMA nodes

Machine Learning and Kubernetes

Kubernetes is a popular way to scale out ML workloads

Good integration in popular frameworks