Volcano vgpu device plugin for Kubernetes Example

Prerequisites

1. GPU driver has been successfully installed.

```
[root@vgpu-on-volcano yum.repos.d]# nvidia-smi
Sat Sep 14 15:41:44 2024
+-----------------------------------------------------------------------------------------+
| NVIDIA-SMI 550.54.14              Driver Version: 550.54.14      CUDA Version: 12.4     |
|-----------------------------------------+------------------------+----------------------+
| GPU  Name                 Persistence-M | Bus-Id          Disp.A | Volatile Uncorr. ECC |
| Fan  Temp   Perf          Pwr:Usage/Cap |           Memory-Usage | GPU-Util  Compute M. |
|                                         |                        |               MIG M. |
|=========================================+========================+======================|
|   0  Tesla T4                       Off |   00000000:18:00.0 Off |                    0 |
| N/A   73C    P0             33W /   70W |       0MiB /  15360MiB |      0%      Default |
|                                         |                        |                  N/A |
+-----------------------------------------+------------------------+----------------------+
|   1  Tesla T4                       Off |   00000000:5E:00.0 Off |                    0 |
| N/A   61C    P0             29W /   70W |       0MiB /  15360MiB |      0%      Default |
|                                         |                        |                  N/A |
+-----------------------------------------+------------------------+----------------------+
|   2  Tesla T4                       Off |   00000000:AF:00.0 Off |                    0 |
| N/A   71C    P0             33W /   70W |       0MiB /  15360MiB |      0%      Default |
|                                         |                        |                  N/A |
+-----------------------------------------+------------------------+----------------------+
|   3  Tesla T4                       Off |   00000000:D8:00.0 Off |                    0 |
| N/A   68C    P0             32W /   70W |       0MiB /  15360MiB |      8%      Default |
|                                         |                        |                  N/A |
+-----------------------------------------+------------------------+----------------------+

+-----------------------------------------------------------------------------------------+
| Processes:                                                                              |
|  GPU   GI   CI        PID   Type   Process name                              GPU Memory |
|        ID   ID                                                               Usage      |
|=========================================================================================|
|  No running processes found                                                             |
+-----------------------------------------------------------------------------------------+
```

2. Nvidia-container-toolkit has been installed. Make sure default-runtime is set to nvidia in /etc/docker/daemon.json(Rememeber to restart docker service after the change)

```
{
    "default-runtime": "nvidia",
    "runtimes": {
        "nvidia": {
            "path": "nvidia-container-runtime",
            "runtimeArgs": []
        }
    }
}
```

3. Kubernetes has been properly installed and is functioning normally.

```
[root@vgpu-on-volcano registry]# kubectl get node
NAME            STATUS   ROLES           AGE   VERSION
172.27.231.43   Ready    control-plane   45m   v1.24.14
[root@vgpu-on-volcano registry]# kubectl get pods -A
NAMESPACE           NAME                                      READY   STATUS    RESTARTS   AGE
kube-system         coredns-c5dfc987b-8wb6x                   1/1     Running   0          43m
kube-system         dns-autoscaler-74ffc79f79-sqh8m           1/1     Running   0          43m
kube-system         kube-apiserver-172.27.231.43              1/1     Running   0          45m
kube-system         kube-controller-manager-172.27.231.43     1/1     Running   1          45m
kube-system         kube-flannel-bpgkw                        1/1     Running   0          18m
kube-system         kube-proxy-czgvh                          1/1     Running   0          44m
kube-system         kube-scheduler-172.27.231.43              1/1     Running   1          45m
kube-system         metrics-server-7bf9d8cb7b-x57wp           1/1     Running   0          42m
kube-system         registry-k24zm                            1/1     Running   0          43m
local-path-storage  local-path-provisioner-7695bf6475-649f6   1/1     Running   0          44m
[root@vgpu-on-volcano registry]# helm repo list
Error: no repositories to show
[root@vgpu-on-volcano registry]#
```

Volcano Installation

1. Make sure volcano version is higher than v1.9.0
2. You can follow the volcano installation documentation: https://volcano.sh/en/docs/v1-9-0/installation/
    - helm repo add volcano-sh https://volcano-sh.github.io/helm-charts
    - helm repo update
    - helm install volcano volcano-sh/volcano --version 1.9.0 -n volcano-system --create-namespace

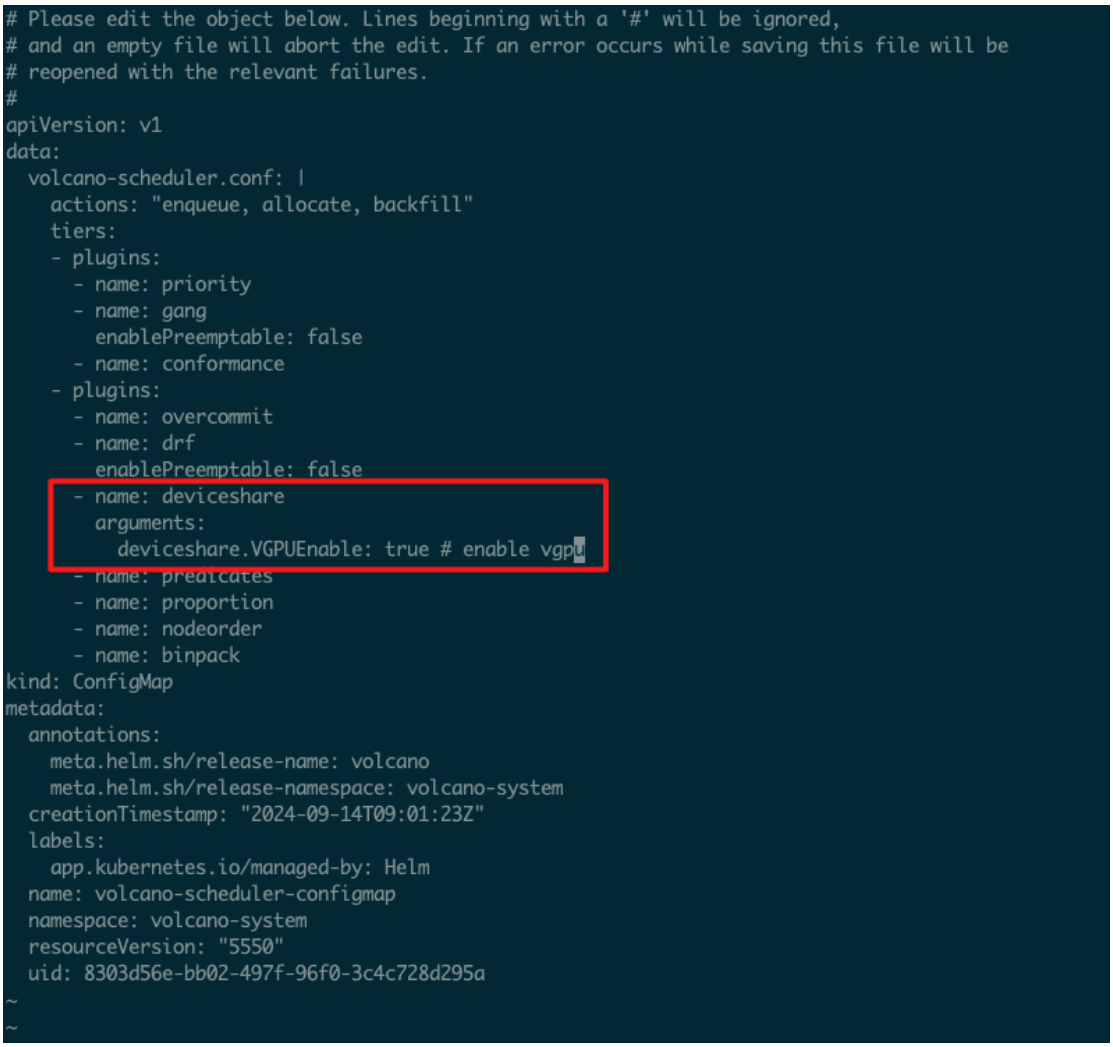
```
[root@vgpu-on-volcano registry]# helm repo add volcano-sh https://volcano-sh.github.io/helm-charts
"volcano-sh" has been added to your repositories
[root@vgpu-on-volcano registry]# helm repo update

Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "volcano-sh" chart repository
Update Complete. *Happy Helming!*
[root@vgpu-on-volcano registry]#
[root@vgpu-on-volcano registry]# helm install volcano volcano-sh/volcano --version 1.9.0 -n volcano-system --create-namespace
NAME: volcano
LAST DEPLOYED: Sat Sep 14 17:01:21 2024
NAMESPACE: volcano-system
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Thank you for installing volcano.

Your release is named volcano.

For more information on volcano, visit:
https://volcano.sh/
```

3. Check if all pods are in running states

```
[root@vgpu-on-volcano registry]# kubectl get pods -n volcano-system
NAME                                   READY   STATUS      RESTARTS   AGE
volcano-admission-76645f6857-phzh4     1/1     Running     0          41s
volcano-admission-init-kglm5           0/1     Completed   0          66s
volcano-controllers-7665d47bcd-wsqg4   1/1     Running     0          18s
volcano-scheduler-676c458795-dmtvr     1/1     Running     0          3s
```

Volcano-vgpu-device-plugin Installation

1. You can follow the volcano-vgpu-device-plugin installation documentation: https://github.com/Project-HAMi/volcano-vgpu-device-plugin?tab=readme-ov-file#enabling-gpu-support-in-kubernetes
    - kubectl edit cm -n volcano-system volcano-scheduler-configmap



- Save volcano-vgpu-device-plugin.yml to local

```
# Copyright (c) 2019, NVIDIA CORPORATION.  All rights reserved.
#
# Licensed under the Apache License, Version 2.0 (the "License");
# you may not use this file except in compliance with the License.
# You may obtain a copy of the License at
#
#     http://www.apache.org/licenses/LICENSE-2.0
#
# Unless required by applicable law or agreed to in writing,
software
# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
implied.
# See the License for the specific language governing permissions
and
# limitations under the License.

---
apiVersion: v1
kind: ServiceAccount
metadata:
```

```
  name: volcano-device-plugin
  namespace: kube-system
---
kind: ClusterRole
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: volcano-device-plugin
rules:
- apiGroups: [""]
  resources: ["nodes"]
  verbs: ["get", "list", "watch", "update", "patch"]
- apiGroups: [""]
  resources: ["nodes/status"]
  verbs: ["patch"]
- apiGroups: [""]
  resources: ["pods"]
  verbs: ["get", "list", "update", "patch", "watch"]
---
kind: ClusterRoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: volcano-device-plugin
subjects:
- kind: ServiceAccount
  name: volcano-device-plugin
  namespace: kube-system
roleRef:
  kind: ClusterRole
  name: volcano-device-plugin
  apiGroup: rbac.authorization.k8s.io
---
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: volcano-device-plugin
  namespace: kube-system
spec:
  selector:
    matchLabels:
      name: volcano-device-plugin
  updateStrategy:
    type: RollingUpdate
  template:
    metadata:
      # This annotation is deprecated. Kept here for backward
compatibility
      # See https://kubernetes.io/docs/tasks/administer-
cluster/guaranteed-scheduling-critical-addon-pods/
      annotations:
```

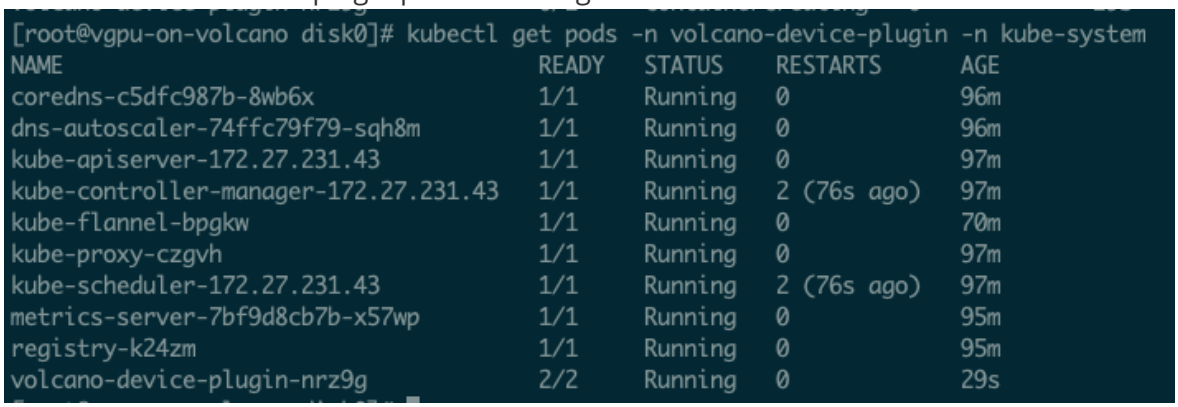
```
        scheduler.alpha.kubernetes.io/critical-pod: ""
      labels:
        name: volcano-device-plugin
    spec:
      tolerations:
      # This toleration is deprecated. Kept here for backward
compatibility
      # See https://kubernetes.io/docs/tasks/administer-
cluster/guaranteed-scheduling-critical-addon-pods/
      - key: CriticalAddonsOnly
        operator: Exists
      - key: volcano.sh/gpu-memory
        operator: Exists
        effect: NoSchedule
      # Mark this pod as a critical add-on; when enabled, the
critical add-on
      # scheduler reserves resources for critical add-on pods so
that they can
      # be rescheduled after a failure.
      # See https://kubernetes.io/docs/tasks/administer-
cluster/guaranteed-scheduling-critical-addon-pods/
      priorityClassName: "system-node-critical"
      serviceAccount: volcano-device-plugin
      containers:
      - image: docker.io/projecthami/volcano-vgpu-device-
plugin:latest
        args: ["--device-split-count=10"]
        lifecycle:
          postStart:
            exec:
              command: ["/bin/sh", "-c", "cp -f /k8s-
vgpu/lib/nvidia/* /usr/local/vgpu/"]
        name: volcano-device-plugin
        env:
        - name: NODE_NAME
          valueFrom:
            fieldRef:
              fieldPath: spec.nodeName
        - name: HOOK_PATH
          value: "/usr/local/vgpu"
        securityContext:
          allowPrivilegeEscalation: false
          capabilities:
            drop: ["ALL"]
            add: ["SYS_ADMIN"]
        volumeMounts:
        - name: device-plugin
          mountPath: /var/lib/kubelet/device-plugins
        - name: lib
```

```
          mountPath: /usr/local/vgpu
        - name: hosttmp
          mountPath: /tmp
      - image: docker.io/projecthami/volcano-vgpu-device-
plugin:latest
        name: monitor
        command:
        - /bin/bash
        - -c
        - volcano-vgpu-monitor
        env:
        - name: NVIDIA_VISIBLE_DEVICES
          value: "all"
        - name: NVIDIA_MIG_MONITOR_DEVICES
          value: "all"
        - name: HOOK_PATH
          value: "/tmp/vgpu"
        - name: NODE_NAME
          valueFrom:
            fieldRef:
              fieldPath: spec.nodeName
        securityContext:
          allowPrivilegeEscalation: false
          capabilities:
            drop: ["ALL"]
            add: ["SYS_ADMIN"]
        volumeMounts:
        - name: dockers
          mountPath: /run/docker
        - name: containerds
          mountPath: /run/containerd
        - name: sysinfo
          mountPath: /sysinfo
        - name: hostvar
          mountPath: /hostvar
        - name: hosttmp
          mountPath: /tmp
      volumes:
      - hostPath:
          path: /var/lib/kubelet/device-plugins
          type: Directory
        name: device-plugin
      - hostPath:
          path: /usr/local/vgpu
          type: DirectoryOrCreate
        name: lib
      - name: hosttmp
        hostPath:
          path: /tmp
```

```
            type: DirectoryOrCreate
        - name: dockers
          hostPath:
            path: /run/docker
            type: DirectoryOrCreate
        - name: containerds
          hostPath:
            path: /run/containerd
            type: DirectoryOrCreate
        - name: usrbin
          hostPath:
            path: /usr/bin
            type: Directory
        - name: sysinfo
          hostPath:
            path: /sys
            type: Directory
        - name: hostvar
          hostPath:
            path: /var
            type: Directory
```

- kubectl create -f volcano-vgpu-device-plugin.yml

2. Check if volcano-device-plugin pod in running states



3. Check node status

Running VGPU Jobs

1. Running a demo vgpu job

```
cat <<EOF | kubectl apply -f -
kind: Job
metadata:
  name: gpu-compute-job
spec:
  template:
    spec:
      schedulerName: volcano
      restartPolicy: OnFailure
      containers:
      - name: tensorflow-gpu
        image: tensorflow/tensorflow:latest-gpu  # 使用 TensorFlow GPU
镜像
        command:
          - python
          - -c
          - |
            import tensorflow as tf
            (x_train, y_train), (x_test, y_test) =
tf.keras.datasets.mnist.load_data()
```

```
            model = tf.keras.models.Sequential([
                tf.keras.layers.Flatten(input_shape=(28, 28)),
                tf.keras.layers.Dense(128, activation='relu'),
                tf.keras.layers.Dense(10, activation='softmax')
            ])
            model.compile(optimizer='adam',
loss='sparse_categorical_crossentropy', metrics=['accuracy'])
            model.fit(x_train, y_train, epochs=5)
            model.evaluate(x_test, y_test)
        resources:
          limits:
            volcano.sh/vgpu-number: 2 # requesting 2 gpu cards
            volcano.sh/vgpu-memory: 3000 # (optinal)each vGPU uses 3G
device memory
            volcano.sh/vgpu-cores: 50 # (optional)each vGPU uses 50%
core
EOF
```

2. Check pod status

```
[root@vgpu-on-volcano worspace]# kubectl get pod -A
NAMESPACE             NAME                                      READY   STATUS      RESTARTS        AGE
default               gpu-pod1                                  1/1     Running     0               4s
kube-system           coredns-c5dfc987b-8wb6x                   1/1     Running     0               3d23h
kube-system           dns-autoscaler-74ffc79f79-sqh8m           1/1     Running     0               3d23h
kube-system           kube-apiserver-172.27.231.43              1/1     Running     0               3d23h
kube-system           kube-controller-manager-172.27.231.43     1/1     Running     2 (3d21h ago)   3d23h
kube-system           kube-flannel-bpgkw                        1/1     Running     0               3d22h
kube-system           kube-proxy-czgvh                          1/1     Running     0               3d23h
kube-system           kube-scheduler-172.27.231.43              1/1     Running     2 (3d21h ago)   3d23h
kube-system           metrics-server-7bf9d8cb7b-x57wp           1/1     Running     0               3d23h
kube-system           registry-k24zm                            1/1     Running     0               3d23h
kube-system           volcano-device-plugin-nrz9g               2/2     Running     0               3d21h
local-path-storage    local-path-provisioner-7695bf6475-649f6   1/1     Running     1 (3d21h ago)   3d23h
volcano-system        volcano-admission-76645f6857-phzh4        1/1     Running     0               3d22h
volcano-system        volcano-admission-init-kglm5              0/1     Completed   0               3d22h
volcano-system        volcano-controllers-7665d47bcd-wsqg4      1/1     Running     0               3d22h
volcano-system        volcano-scheduler-676c458795-dmtvr        1/1     Running     0               3d22h
```

3. Check node status

```
Non-terminated Pods:          (15 in total)
  Namespace                   Name                                      CPU Requests  CPU Limits  Memory Requests  Memory Limits  Age
  ---------                   ----                                      ------------  ----------  ---------------  -------------  ---
  default                     gpu-compute-job-zjh7p                     0 (0%)        0 (0%)      0 (0%)           0 (0%)         19s
  kube-system                 coredns-c5dfc987b-8wb6x                   100m (0%)     0 (0%)      70Mi (0%)        300Mi (0%)     9d
  kube-system                 dns-autoscaler-74ffc79f79-sqh8m           20m (0%)      0 (0%)      10Mi (0%)        0 (0%)         9d
  kube-system                 kube-apiserver-172.27.231.43              250m (0%)     0 (0%)      0 (0%)           0 (0%)         9d
  kube-system                 kube-controller-manager-172.27.231.43     200m (0%)     0 (0%)      0 (0%)           0 (0%)         9d
  kube-system                 kube-flannel-bpgkw                        150m (0%)     300m (0%)   64M (0%)         500M (0%)      9d
  kube-system                 kube-proxy-czgvh                          0 (0%)        0 (0%)      0 (0%)           0 (0%)         9d
  kube-system                 kube-scheduler-172.27.231.43              100m (0%)     0 (0%)      0 (0%)           0 (0%)         9d
  kube-system                 metrics-server-7bf9d8cb7b-x57wp           100m (0%)     100m (0%)   200Mi (0%)       200Mi (0%)     9d
  kube-system                 registry-k24zm                            0 (0%)        0 (0%)      0 (0%)           0 (0%)         9d
  kube-system                 volcano-device-plugin-4m2pq               0 (0%)        0 (0%)      0 (0%)           0 (0%)         3h48m
  local-path-storage          local-path-provisioner-7695bf6475-649f6   0 (0%)        0 (0%)      0 (0%)           0 (0%)         9d
  volcano-system              volcano-admission-746fcd6465-7b8d9        0 (0%)        0 (0%)      0 (0%)           0 (0%)         31m
  volcano-system              volcano-controllers-8568d848bb-cjp5n      0 (0%)        0 (0%)      0 (0%)           0 (0%)         30m
  volcano-system              volcano-scheduler-847c49b697-x5m8r        0 (0%)        0 (0%)      0 (0%)           0 (0%)         29m
Allocated resources:
  (Total limits may be over 100 percent, i.e., overcommitted.)
  Resource                    Requests       Limits
  --------                    --------       ------
  cpu                         920m (0%)      400m (0%)
  memory                      349220Ki (0%)  1024288000 (0%)
  ephemeral-storage           0 (0%)         0 (0%)
  hugepages-1Gi               0 (0%)         0 (0%)
  hugepages-2Mi               0 (0%)         0 (0%)
  volcano.sh/vgpu-cores       50             50
  volcano.sh/vgpu-memory      3k             3k
  volcano.sh/vgpu-number      2              2
Events:                       <none>
[root@vgpu-on-volcano disk0]#
```

4. Running nvidia-smi command in container to check if its using vgpu resource

```
[HAMI-core Msg(499:140364847019840:libvgpu.c:836)]: Initializing.....
Tue Sep 24 07:24:11 2024
+-----------------------------------------------------------------------------------------+
| NVIDIA-SMI 550.54.14              Driver Version: 550.54.14      CUDA Version: 12.4     |
|-----------------------------------------+------------------------+----------------------+
| GPU  Name                 Persistence-M | Bus-Id          Disp.A | Volatile Uncorr. ECC |
| Fan  Temp   Perf          Pwr:Usage/Cap |           Memory-Usage | GPU-Util  Compute M. |
|                                         |                        |               MIG M. |
|=========================================+========================+======================|
|   0  Tesla T4                       Off |   00000000:AF:00.0 Off |                    0 |
| N/A   40C    P0             34W /   70W |    1966MiB /   3000MiB |      0%      Default |
|                                         |                        |                  N/A |
+-----------------------------------------+------------------------+----------------------+
|   1  Tesla T4                       Off |   00000000:D8:00.0 Off |                    0 |
| N/A   42C    P0             27W /   70W |       0MiB /   3000MiB |      0%      Default |
|                                         |                        |                  N/A |
+-----------------------------------------+------------------------+----------------------+


+-----------------------------------------------------------------------------------------+
| Processes:                                                                              |
|  GPU   GI   CI        PID   Type   Process name                              GPU Memory |
|        ID   ID                                                               Usage      |
|=========================================================================================|
|    0   N/A  N/A         1      C   python                                        0MiB |
|    1   N/A  N/A         1      C   python                                        0MiB |
+-----------------------------------------------------------------------------------------+
[HAMI-core Msg(499:140364847019840:multiprocess_memory_limit.c:497)]: Calling exit handler 499
root@gpu-compute-job-7j8ll:/#
```

5. Check pod logs

```
 one has already been registered
2024-09-23 09:27:27.743200: E external/local_xla/xla/stream_executor/cuda/cuda_blas.cc:1452] Unable to register cuBLAS factory: Attempting to register factory for plugin cuBLAS w
hen one has already been registered
2024-09-23 09:27:27.755806: I tensorflow/core/platform/cpu_feature_guard.cc:210] This TensorFlow binary is optimized to use available CPU instructions in performance-critical ope
rations.
To enable the following instructions: AVX2 AVX512F AVX512_VNNI FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.
[HAMI-core Msg(1:140339026199552:libvgpu.c:836)]: Initializing.....
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 3s 0us/step
/usr/local/lib/python3.11/dist-packages/keras/src/layers/reshaping/flatten.py:37: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential
 models, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(**kwargs)
[HAMI-core Msg(1:140339026199552:libvgpu.c:855)]: Initialized
[HAMI-core Msg(1:140339026199552:memory.c:511)]: orig free=15534391296 total=15642329088 limit=3145728000 usage=0
[HAMI-core Msg(1:140339026199552:memory.c:511)]: orig free=15534391296 total=15642329088 limit=3145728000 usage=0
2024-09-23 09:27:34.249969: I tensorflow/core/common_runtime/gpu/gpu_device.cc:2021] Created device /job:localhost/replica:0/task:0/device:GPU:0 with 1950 MB memory:  -> device:
0, name: Tesla T4, pci bus id: 0000:af:00.0, compute capability: 7.5
2024-09-23 09:27:34.252410: I tensorflow/core/common_runtime/gpu/gpu_device.cc:2021] Created device /job:localhost/replica:0/task:0/device:GPU:1 with 1950 MB memory:  -> device:
1, name: Tesla T4, pci bus id: 0000:d8:00.0, compute capability: 7.5
Epoch 1/5
WARNING: All log messages before absl::InitializeLog() is called are written to STDERR
I0000 00:00:1727083654.975791     270 service.cc:146] XLA service 0x7f9e380191f0 initialized for platform CUDA (this does not guarantee that XLA will be used). Devices:
I0000 00:00:1727083654.975888     270 service.cc:154]   StreamExecutor device (0): Tesla T4, Compute Capability 7.5
I0000 00:00:1727083654.975909     270 service.cc:154]   StreamExecutor device (1): Tesla T4, Compute Capability 7.5
2024-09-23 09:27:35.008764: I tensorflow/compiler/mlir/tensorflow/utils/dump_mlir_util.cc:268] disabling MLIR crash reproducer, set env var `MLIR_CRASH_REPRODUCER_DIRECTORY` to e
nable.
2024-09-23 09:27:35.095957: I external/local_xla/xla/stream_executor/cuda/cuda_dnn.cc:531] Loaded cuDNN version 8906
I0000 00:00:1727083655.809834     270 device_compiler.h:188] Compiled cluster using XLA!  This line is logged at most once for the lifetime of the process.
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 5s 2ms/step - accuracy: 0.8255 - loss: 7.9226
Epoch 2/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.9097 - loss: 0.3842
Epoch 3/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.9331 - loss: 0.2653
Epoch 4/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.9380 - loss: 0.2400
Epoch 5/5
1875/1875 ━━━━━━━━━━━━━━━━━━━━ 3s 2ms/step - accuracy: 0.9461 - loss: 0.2101
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step - accuracy: 0.9311 - loss: 0.2824
[HAMI-core Msg(1:140339026199552:multiprocess_memory_limit.c:497)]: Calling exit handler 1
[root@vgpu-on-volcano disk0]#
```

Monitor

1. volcano-scheduler-metrics records every GPU usage and limitation, visit the following address to get these metrics.

```
curl {volcano scheduler cluster ip}:8080/metrics
```

```
volcano_task_scheduling_latency_milliseconds_bucket{le="2560"} 16
volcano_task_scheduling_latency_milliseconds_bucket{le="+Inf"} 16
volcano_task_scheduling_latency_milliseconds_sum 19838.025477999996
volcano_task_scheduling_latency_milliseconds_count 16
# HELP volcano_total_preemption_attempts Total preemption attempts in the cluster till now
# TYPE volcano_total_preemption_attempts counter
volcano_total_preemption_attempts 0
# HELP volcano_unschedule_job_count Number of jobs could not be scheduled
# TYPE volcano_unschedule_job_count gauge
volcano_unschedule_job_count 0
# HELP volcano_unschedule_task_count Number of tasks could not be scheduled
# TYPE volcano_unschedule_task_count gauge
volcano_unschedule_task_count{job_id="podgroup-c530b3aa-24b4-47e1-abd6-1c99abdddbc0"} 0
volcano_unschedule_task_count{job_id="podgroup-fe02f37c-0749-4738-a7d7-3fde6804ca68"} 0
# HELP volcano_vgpu_device_allocated_cores The percentage of gpu compute cores allocated in this card
# TYPE volcano_vgpu_device_allocated_cores gauge
volcano_vgpu_device_allocated_cores{devID="GPU-13cdd923-0935-e4ea-e227-5da4121fd870"} 50
volcano_vgpu_device_allocated_cores{devID="GPU-2d9ec792-5a6d-4a0c-672c-54ebc7ff7a7b"} 0
volcano_vgpu_device_allocated_cores{devID="GPU-47eca37f-5be3-39ce-c8df-5b4580733713"} 50
volcano_vgpu_device_allocated_cores{devID="GPU-a969d415-49da-7c8a-7d6e-d27f3134fa88"} 0
# HELP volcano_vgpu_device_allocated_memory The number of vgpu memory allocated in this card
# TYPE volcano_vgpu_device_allocated_memory gauge
volcano_vgpu_device_allocated_memory{devID="GPU-13cdd923-0935-e4ea-e227-5da4121fd870"} 3000
volcano_vgpu_device_allocated_memory{devID="GPU-2d9ec792-5a6d-4a0c-672c-54ebc7ff7a7b"} 0
volcano_vgpu_device_allocated_memory{devID="GPU-47eca37f-5be3-39ce-c8df-5b4580733713"} 3000
volcano_vgpu_device_allocated_memory{devID="GPU-a969d415-49da-7c8a-7d6e-d27f3134fa88"} 0
# HELP volcano_vgpu_device_memory_limit The number of total device memory allocated in this card
# TYPE volcano_vgpu_device_memory_limit gauge
volcano_vgpu_device_memory_limit{devID="GPU-13cdd923-0935-e4ea-e227-5da4121fd870"} 15360
volcano_vgpu_device_memory_limit{devID="GPU-2d9ec792-5a6d-4a0c-672c-54ebc7ff7a7b"} 15360
volcano_vgpu_device_memory_limit{devID="GPU-47eca37f-5be3-39ce-c8df-5b4580733713"} 15360
volcano_vgpu_device_memory_limit{devID="GPU-a969d415-49da-7c8a-7d6e-d27f3134fa88"} 15360
# HELP volcano_vgpu_device_shared_number The number of vgpu tasks sharing this card
# TYPE volcano_vgpu_device_shared_number gauge
volcano_vgpu_device_shared_number{devID="GPU-13cdd923-0935-e4ea-e227-5da4121fd870"} 1
volcano_vgpu_device_shared_number{devID="GPU-2d9ec792-5a6d-4a0c-672c-54ebc7ff7a7b"} 0
volcano_vgpu_device_shared_number{devID="GPU-47eca37f-5be3-39ce-c8df-5b4580733713"} 1
volcano_vgpu_device_shared_number{devID="GPU-a969d415-49da-7c8a-7d6e-d27f3134fa88"} 0
```

2. You can also collect the **GPU utilization**, **GPU memory usage**, **pods' GPU memory limitations** and **pods' GPU memory usage** metrics on nodes by visiting the following addresses:

```
curl {volcano device plugin pod ip}:9394/metrics
```

```
Device_last_kernel_of_container{ctrname="tensorflow-gpu",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="1",zone="vGPU"} 2
Device_last_kernel_of_container{ctrname="tensorflow-gpu",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="0",zone="vGPU"} 2
# HELP Device_memory_desc_of_container Container device meory description
# TYPE Device_memory_desc_of_container counter
Device_memory_desc_of_container{context="0",ctrname="tensorflow-gpu",data="0",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",module="0",offset="0",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="1",zone="vGPU"} 0
Device_memory_desc_of_container{context="0",ctrname="tensorflow-gpu",data="2061772288",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",module="0",offset="0",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="0",zone="vGPU"} 2.061772288e+09
# HELP Device_utilization_desc_of_container Container device utilization description
# TYPE Device_utilization_desc_of_container gauge
Device_utilization_desc_of_container{ctrname="tensorflow-gpu",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="1",zone="vGPU"} 0
Device_utilization_desc_of_container{ctrname="tensorflow-gpu",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="0",zone="vGPU"} 0
# HELP HostCoreUtilization GPU core utilization
# TYPE HostCoreUtilization gauge
HostCoreUtilization{deviceidx="0",deviceuuid="GPU-2d9ec792-5a6d-4a0c-672c-54ebc7ff7a7b",zone="vGPU"} 0
HostCoreUtilization{deviceidx="1",deviceuuid="GPU-a969d415-49da-7c8a-7d6e-d27f3134fa88",zone="vGPU"} 0
HostCoreUtilization{deviceidx="2",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",zone="vGPU"} 10
HostCoreUtilization{deviceidx="3",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",zone="vGPU"} 0
# HELP HostGPUMemoryUsage GPU device memory usage
# TYPE HostGPUMemoryUsage gauge
HostGPUMemoryUsage{deviceidx="0",deviceuuid="GPU-2d9ec792-5a6d-4a0c-672c-54ebc7ff7a7b",zone="vGPU"} 4.63863808e+08
HostGPUMemoryUsage{deviceidx="1",deviceuuid="GPU-a969d415-49da-7c8a-7d6e-d27f3134fa88",zone="vGPU"} 4.63863808e+08
HostGPUMemoryUsage{deviceidx="2",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",zone="vGPU"} 2.641625088e+09
HostGPUMemoryUsage{deviceidx="3",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",zone="vGPU"} 5.71736064e+08
# HELP vGPU_device_memory_limit_in_bytes vGPU device limit
# TYPE vGPU_device_memory_limit_in_bytes gauge
vGPU_device_memory_limit_in_bytes{ctrname="tensorflow-gpu",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="1",zone="vGPU"} 3.145728e+09
vGPU_device_memory_limit_in_bytes{ctrname="tensorflow-gpu",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="0",zone="vGPU"} 3.145728e+09
# HELP vGPU_device_memory_usage_in_bytes vGPU device usage
# TYPE vGPU_device_memory_usage_in_bytes gauge
vGPU_device_memory_usage_in_bytes{ctrname="tensorflow-gpu",deviceuuid="GPU-13cdd923-0935-e4ea-e227-5da4121fd870",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="1",zone="vGPU"} 0
vGPU_device_memory_usage_in_bytes{ctrname="tensorflow-gpu",deviceuuid="GPU-47eca37f-5be3-39ce-c8df-5b4580733713",podname="gpu-compute-job-mjwqk",podnamespace="default",vdeviceid="0",zone="vGPU"} 2.061772288e+09
```