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# Guide: OpenACC on AWS

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## Abstract

This is a guideline document to show the necessary actions to set up the system to use OpenACC in GPU-base accelerated computing instances on AWS.


## Requirements

- **First you should have followed the Guide "First Access to AWS"**. It is assumed you already have an AWS account and a key pair, and you are familiar with the AWS EC2 environment.
- Take into account that **GPU-powered instances are expensive**.


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## 1. Configure the VM

- Launch an instance with "**Ubuntu Server 18.04**" as AMI and "g3.4xlarge" as instance type. This is an instance powered by one NVIDIA Tesla M60 GPU with 8 GiB of GPU memory and 2048 parallel processing cores. [Your default account may not allow you to use any GPUs (including g3.4xlarge). In that case, via "support" on AWS dashboard, request access to g3.4xlarge.]

- You should include the internal hostname and IP to `/etc/hosts`. You will find these under Description once the instance is up and running. In my specific case:

```
$ cat /etc/hosts
127.0.0.1 localhost
172.30.4.157 ip-172-30-4-157
```

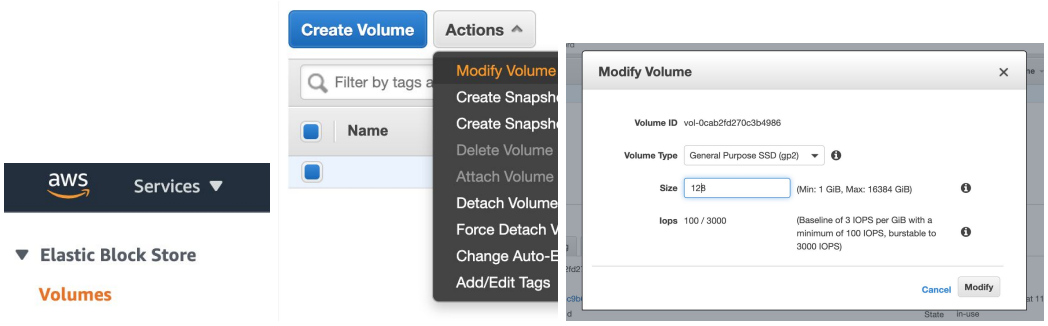
- Check the availability of the GPU within the running instance

```
$ lspci | grep -i nvidia

00:1e.0 VGA compatible controller: NVIDIA Corporation
GM204GL [Tesla M60] (rev a1)
```

- By default the EBS volume is only 8GiB and we need 128GiB.

```
$ df -h

Filesystem      Size  Used Avail Use% Mounted on
udev             60G     0   60G   0% /dev
tmpfs            12G  8.7M   12G   1% /run
/dev/xvda1        8G    6G  4.0G  69% /
```

- Go to the AWS control panel and in the Volumes section of the EC2 dashboard find your EBS partition and resize its volume.



- Then within the running system you have to extend the Linux File System.

```
$ sudo growpart /dev/xvda 1

CHANGED: disk=/dev/xvda partition=1: start=4096 old:
size=16773086,end=16777182 new: size=73396190,end=73400286
```

- A look at the `lsblk` output confirms that the partition `/dev/xvda1` now fills the available space on the volume `/dev/xvda`:

```
$ lsblk

NAME    MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
...
xvda    202:80   0  128G  0 disk
└─xvda1 202:81   0  128G  0 part
```

- Use a file system-specific command to resize each file system to the new volume capacity. For a Linux ext2, ext3, or ext4 file system, use the following command, substituting the device name to extend:

```
$ sudo resize2fs /dev/xvda1
```

- Make sure we have some basic packages installed on Ubuntu

```
$ sudo apt-get update
$ sudo apt-get install build-essential
```

- The `gcc` version I'm using is 7.x

```
$ gcc --version
gcc (Ubuntu 7.5.0-3ubuntu1~18.04) 7.5.0
```

## 2. Install CUDA

- Use `wget` from the EC2 instance

```
$ wget
http://developer.download.nvidia.com/compute/cuda/repos/ubu
ntu1804/x86_64/cuda-repo-ubuntu1804_10.0.130-1_amd64.deb
```

- We should now have a deb file called `cuda-repo-ubuntu1804_10.0.130-1_amd64.deb` in the home directory. Run the following commands to install CUDA:

  ```
  $ sudo dpkg -i cuda-repo-ubuntu1804_10.0.130-1_amd64.deb
  ```

  You may receive a "The public CUDA GPG key does not appear to be installed." error. Please paste and run the command it recommends, which will look something like

  ```
  $ sudo apt-key adv --fetch-keys http://developer.download.nvidia.com/compute/cuda/repos/ubuntu1804/x86_64/7fa2af80.pub
  ```

- Continue your installation with the following commands:

  ```
  $ sudo apt-get update
  $ sudo apt-get install cuda
  ```

- Now you can check the CUDA installation:

  ```
  $ nvidia-smi
  ```

```
Wed Feb 17 05:07:39 2021
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 460.32.03    Driver Version: 460.32.03    CUDA Version: 11.2     |
|-------------------------------+----------------------+----------------------+
| 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 M60           Off  | 00000000:00:1E.0 Off |                    0 |
| N/A   28C    P0    38W / 150W |      0MiB /  7618MiB |     98%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+

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

- This command may take a few seconds to run due to the default configurations being suboptimal. You can follow the steps below to re-configure the GPU settings:
    - Configure the GPU settings to be persistent

```
$ sudo nvidia-smi -pm 1
```

    - Disable the autoboost feature for all GPUs on the instance

```
$ sudo nvidia-smi --auto-boost-default=0
```

    - Set all GPU clock speeds to their maximum frequency

```
$ sudo nvidia-smi -ac 2505,875
```

- Running `nvidia-smi` may now be faster!

## 3. Install NVIDIA HPC SDK

The NVIDIA HPC SDK includes a no-cost license to a recent release of the Fortran, C and C++ compilers and tools for multicore CPUs and NVIDIA Tesla GPUs, including all OpenACC, OpenMP and CUDA Fortran features.

- Install NVIDIA HPC SDK Version 21.1 with the following

```
$ wget
https://developer.download.nvidia.com/hpc-sdk/21.1/nvhpc_2021
_211_Linux_x86_64_cuda_11.2.tar.gz

$ tar xpzf nvhpc_2021_211_Linux_x86_64_cuda_11.2.tar.gz

$ sudo nvhpc_2021_211_Linux_x86_64_cuda_11.2/install
```

  During install you will need to go through the following steps:

  1. You will then be asked if you want to do a single system install or a network. Choose **1 for single system**
  2. Then you will be asked which directory you would like to install in. Press **enter** to keep the default /opt/nvidia/hpc_sdk

- Configure your shell environment.

```
$ export PGI=/opt/nvidia/hpc_sdk;
$ export
PATH=/opt/nvidia/hpc_sdk/Linux_x86_64/21.1/compilers/bin:$PATH;
$ export
MANPATH=$MANPATH:/opt/nvidia/hpc_sdk/Linux_x86_64/21.1/compiler
```

```
s/man;
```

- Run `pgaccelinfo` to see that your GPU and drivers are properly installed and available. For NVIDIA, you should see output that looks something like the following:

```
$ pgaccelinfo
CUDA Driver Version:           11020
NVRM version:                        NVIDIA UNIX x86_64 Kernel Module
460.32.03  Sun Dec 27 19:00:34 UTC 2020

Device Number:                 0
Device Name:                   Tesla M60
Device Revision Number:        5.2
Global Memory Size:            7988903936
Number of Multiprocessors:     16
Concurrent Copy and Execution: Yes
Total Constant Memory:         65536
Total Shared Memory per Block: 49152
Registers per Block:           65536
Warp Size:                     32
Maximum Threads per Block:     1024
Maximum Block Dimensions:      1024, 1024, 64
Maximum Grid Dimensions:       2147483647 x 65535 x 65535
Maximum Memory Pitch:          2147483647B
Texture Alignment:             512B
Clock Rate:                    873 MHz
Execution Timeout:             No
Integrated Device:             No
Can Map Host Memory:           Yes
Compute Mode:                  default
Concurrent Kernels:            Yes
ECC Enabled:                   Yes
Memory Clock Rate:             2505 MHz
Memory Bus Width:              256 bits
L2 Cache Size:                 2097152 bytes
Max Threads Per SMP:           2048
Async Engines:                 2
Unified Addressing:            Yes
Managed Memory:                Yes
Concurrent Managed Memory:     No
Default Target:                cc50
```

## 4. Our First OpenACC Program

- Upload to the VM the [acc_sc.c](#) code, compile it with `pgcc`, and run the code on the GPU. Use

options `-acc` to support OpenACC and `-Minfo` to provide verbose info:

```
$ pgcc -acc -Minfo acc_sc.c -o acc_sc
```

```
vecaddgpu:
      4, Generating copyin(a[:n])
         Generating copyout(r[:n])
         Generating copyin(b[:n])
      5, Loop is parallelizable
         Accelerator kernel generated
         Generating Tesla code
       5, #pragma acc loop gang, vector(128)/* blockIdx.x threadIdx.x */
```

- Run the code

```
$ ./acc_sc
```

- You should see the output

```
0 errors found
```

- You can enable additional output by setting environment variables.

```
$ export PGI_ACC_NOTIFY=1
```

- Run the code again and you should see the output

```
launch      CUDA      kernel            file=/home/ubuntu/acc_sc.c
   function=vecaddgpu  line=5  device=0  threadid=1  num_gangs=782
   num_workers=1 vector_length=128 grid=782 block=128

0 errors found
```

- The extra output tells you that the program launched a kernel for the loop at line 5, with a CUDA grid of size 782, and a thread block of size 128.

- if you set the environment variable `PGI_ACC_NOTIFY` to 3, the output will include information about the data transfers as well:

```
upload CUDA data  file=/home/ubuntu/acc_sc.c function=vecaddgpu
   line=3 device=0 threadid=1 variable=a bytes=400000

upload CUDA data  file=/home/ubuntu/acc_sc.c function=vecaddgpu
   line=3 device=0 threadid=1 variable=b bytes=400000

launch      CUDA      kernel            file=/home/ubuntu/acc_sc.c
   function=vecaddgpu  line=5  device=0  threadid=1  num_gangs=782
   num_workers=1 vector_length=128 grid=782 block=128
```

```
download      CUDA      data            file=/home/ubuntu/acc_sc.c
   function=vecaddgpu   line=5   device=0   threadid=1   variable=r
   bytes=400000

0 errors found
```

- If you set the environment variable `PGI_ACC_TIME` to 1 (`export PGI_ACC_TIME=1`), the runtime summarizes the time taken for data movement between the host and GPU, and computation on the GPU.

```
Accelerator Kernel Timing data

/home/ubuntu/acc_sc.c

  vecaddgpu  NVIDIA  devicenum=0

    time(us): 149

    3: compute region reached 1 time

        5: kernel launched 1 time

            grid: [782]  block: [128]

             device time(us): total=8 max=8 min=8 avg=8

            elapsed time(us): total=679 max=679 min=679 avg=679

    3: data region reached 2 times

        3: data copyin transfers: 2

             device time(us): total=93 max=51 min=42 avg=46

        5: data copyout transfers: 1

             device time(us): total=48 max=48 min=48 avg=48
```

- This tells you that the program entered one accelerator region and spent a total of about `149` microseconds in that region. It copied two arrays to the device, launched one kernel and brought one array back to the host.

**Stop** your instances when are done for the day to avoid

incurring charges
**Terminate** them when you are sure you are done with your instance