The OSU College of Engineering DGX System for Advanced GPU Computing

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OSU’s College of Engineering has six Nvidia DGX-2 systems

Each DGX server:
- Has 16 NVidia Tesla V100 GPUs
- Has 28TB of disk, all SSD
- Has two 24-core Intel Xeon 8168 Platinum 2.7GHz CPUs
- Has 1.5TB of DDR4-2666 System Memory
- Runs the CentOS 7 Linux operating system

Overall compute power:
- Each V100 NVidia Tesla card has 5,120 CUDA Cores and 640 Tensor Cores
- This gives each 16-V100 DGX server a total of 81,920 CUDA cores and 10,240 Tensor cores
- This gives the entire 6-DGX package a total of 491,520 CUDA Cores and 61,440 Tensor Cores
Performance Comparison with one of our previous Systems

BTW, you can also use the *rabbit* machine:

```
ssh rabbit.engr.oregonstate.edu
```

It is a good place to write your code and get it to compile. It is *not* a good place to do the final run of your code.
How to SSH to the DGX Systems

`flip3 151% ssh submit-c.hpc.engr.oregonstate.edu`

`submit-c 142% module load slurm`

SSH over to a DGX submission machine -- `submit-a` and `submit-b` will also work.

Type this right away to set your path correctly.
# How to Check on the DGX Systems

## Check on the queues

```
submit-c 143% squeue
```

<table>
<thead>
<tr>
<th>JOBID</th>
<th>PARTITION</th>
<th>NAME</th>
<th>USER</th>
<th>ST</th>
<th>TIME</th>
<th>NODES</th>
<th>NODELIST(REASON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3923</td>
<td>mime4</td>
<td>c_only</td>
<td>jayasurw</td>
<td>R</td>
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<td>1</td>
<td>compute-e-1</td>
</tr>
<tr>
<td>3963</td>
<td>mime4</td>
<td>2Dex</td>
<td>jayasurw</td>
<td>R</td>
<td>16:21:03</td>
<td>1</td>
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<tr>
<td>3876</td>
<td>share</td>
<td>CH3COOH</td>
<td>chukwuk</td>
<td>R</td>
<td>1-23:36:45</td>
<td>1</td>
<td>compute-2-6</td>
</tr>
<tr>
<td>3971</td>
<td>nerhp</td>
<td>tcsh</td>
<td>dionnec</td>
<td>R</td>
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<tr>
<td>3881</td>
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<td>bash</td>
<td>heli</td>
<td>R</td>
<td>1-22:50:44</td>
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<td>compute-dgx2-1</td>
</tr>
<tr>
<td>3965</td>
<td>dgx2</td>
<td>bash</td>
<td>chenju3</td>
<td>R</td>
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<td>1</td>
<td>compute-dgx2-4</td>
</tr>
<tr>
<td>3645</td>
<td>dgx2</td>
<td>bash</td>
<td>mishrash</td>
<td>R</td>
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<tr>
<td>3585</td>
<td>dgx2</td>
<td>bash</td>
<td>azieren</td>
<td>R</td>
<td>6-17:34:00</td>
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<tr>
<td>3583</td>
<td>dgx2</td>
<td>bash</td>
<td>azieren</td>
<td>R</td>
<td>6-18:26:44</td>
<td>1</td>
<td>compute-dgx2-3</td>
</tr>
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</table>

## System Information

```
submit-c 144% sinfo
```

<table>
<thead>
<tr>
<th>PARTITION</th>
<th>AVAIL</th>
<th>TIMELIMIT</th>
<th>NODES</th>
<th>STATE</th>
<th>NODELIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>share*</td>
<td>up</td>
<td>7-00:00:00</td>
<td>2</td>
<td>drain</td>
<td>compute-4-[3-4]</td>
</tr>
<tr>
<td>share*</td>
<td>up</td>
<td>7-00:00:00</td>
<td>1</td>
<td>mix</td>
<td>compute-2-6</td>
</tr>
<tr>
<td>sharegpu</td>
<td>up</td>
<td>7-00:00:00</td>
<td>1</td>
<td>mix</td>
<td>compute-dgxs-1</td>
</tr>
<tr>
<td>sharegpu</td>
<td>up</td>
<td>7-00:00:00</td>
<td>3</td>
<td>idle</td>
<td>compute-dgxs-[2-3],compute-gpu</td>
</tr>
<tr>
<td>dgx2</td>
<td>up</td>
<td>7-00:00:00</td>
<td>1</td>
<td>drain</td>
<td>compute-dgx2-2</td>
</tr>
<tr>
<td>dgx2</td>
<td>up</td>
<td>7-00:00:00</td>
<td>5</td>
<td>mix</td>
<td>compute-dgx2-[1,3-6]</td>
</tr>
<tr>
<td>gpu</td>
<td>up</td>
<td>7-00:00:00</td>
<td>2</td>
<td>mix</td>
<td>compute-gpu[3-4]</td>
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<tr>
<td>gpu</td>
<td>up</td>
<td>7-00:00:00</td>
<td>1</td>
<td>idle</td>
<td>compute-gpu2</td>
</tr>
<tr>
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<tr>
<td>dgx</td>
<td>up</td>
<td>7-00:00:00</td>
<td>3</td>
<td>mix</td>
<td>compute-dgx2-[4-6]</td>
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<tr>
<td>dgxs</td>
<td>up</td>
<td>7-00:00:00</td>
<td>1</td>
<td>mix</td>
<td>compute-dgxs-1</td>
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<tr>
<td>dgxs</td>
<td>up</td>
<td>7-00:00:00</td>
<td>2</td>
<td>idle</td>
<td>compute-dgxs-[2-3]</td>
</tr>
<tr>
<td>class</td>
<td>up</td>
<td>1:00:00</td>
<td>1</td>
<td>mix</td>
<td>compute-dgxs-1</td>
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<td>up</td>
<td>1:00:00</td>
<td>2</td>
<td>idle</td>
<td>compute-dgxs-[2-3]</td>
</tr>
<tr>
<td>eecs</td>
<td>up</td>
<td>7-00:00:00</td>
<td>1</td>
<td>mix</td>
<td>compute-2-6</td>
</tr>
</tbody>
</table>

## Your partitions

*Oregon State University*  
*Computer Graphics*
Submitting a CUDA job to the DGX Systems using Slurm

Create a bash shell file that looks like this:

```bash
#!/bin/bash
#SBATCH  -J  MatrixMult
#SBATCH  -A  cs475-575
#SBATCH  -p  class
#SBATCH  --gres=gpu:1
#SBATCH  -o  matrixmul.out
#SBATCH  -e  matrixmul.err
#SBATCH  --mail-type=BEGIN,END,FAIL
#SBATCH  --mail-user=joeparallel@oregonstate.edu
/usr/local/apps/cuda/cuda-10.1/bin/nvcc -o matrixMul matrixMul.cu
./matrixMul
```

Note: A single dash (-) is used for a single character flag. A double dash (--) is used for a word (more than a single character) flag.

Your Job Name

Our class account

This is the partition name that we use for classes

Double dash

These 2 lines are actual bash code:

```
submit-c 143% sbatch submit.bash
Submitted batch job 474
```

Submit the job described in your shell file

```
submit-c 144% cat matrixmul.err
```

Check the output
(I like sending my output to standard error, not standard output)
You don’t have to do this, but if you do, please be sure you get your own email address right!

Our IT people are getting real tired of fielding the bounced emails when people spell their own email address wrong.
<table>
<thead>
<tr>
<th>From</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurm workload manager</td>
<td>Slurm Job_id=3980 Name=MatrixMul Ended, Run time 00:00:12, COMPLETED, ExitCode 0</td>
</tr>
<tr>
<td>Slurm workload manager</td>
<td>Slurm Job_id=3980 Name=MatrixMul Began, Queued time 00:00:01</td>
</tr>
</tbody>
</table>
Submitting a Loop

submitloop.bash:

```bash
#!/bin/bash
#SBATCH -J MatrixMul
#SBATCH -A cs475-575
#SBATCH -p class
#SBATCH --gres=gpu:1
#SBATCH -o matrixmul.out
#SBATCH -e matrixmul.err
#SBATCH --mail-type=BEGIN,END,FAIL
#SBATCH --mail-user=joeparallel@oregonstate.edu

for t in 1 2 4 8 16 32
do
    /usr/local/apps/cuda/cuda-10.1/bin/nvcc -DNUMT=$t -o matrixMul matrixMul.cu
    ./matrixMul
done
```

These 5 lines are actual bash code

submit-c 153% sbatch submitloop.bash
Submitted batch job 475

submit-c 154% tail -f matrixmul.err
Displays the latest output added to matrixmul.err. Keeps doing it forever.

Control-c to get out of it.
Results for Multiplying two 1024x1024 Matrices: Varying the CUDA Block Size

GigaFlops during Matrix Multiplication

GigaFlops

NUMT
(Each CUDA block was actually NUMTxNUMT threads)
Use slurm’s *scancel* if your Job Needs to Be Killed

```bash
submit-c 163% sbatch submitloop.bash
Submitted batch job 476

submit-c 164% scancel 476
```
submit.bash:

#!/bin/bash
#SBATCH  -J  MatrixMult
#SBATCH  -A  cs475-575
#SBATCH  -p  class
#SBATCH  --gres=gpu:1
#SBATCH  -o  printinfo.out
#SBATCH  -e  printinfo.err
#SBATCH  --mail-type=BEGIN,END,FAIL
#SBATCH  --mail-user=joeparallel@oregonstate.edu

g++ -o printinfo printinfo.cpp /usr/local/apps/cuda/cuda-10.1/lib64/libOpenCL.so.1.1 -lm -fopenmp
./printinfo
Here’s what `printinfo` got on one graphics card on the DGX System

Number of Platforms = 1

**Platform #0:**
- Name = 'NVIDIA CUDA'
- Vendor = 'NVIDIA Corporation'
- Version = OpenCL 1.2 CUDA 11.2.153'
- Profile = 'FULL_PROFILE'
- Number of Devices = 1

**Device #0:**
- Type = 0x0004 = CL_DEVICE_TYPE_GPU
- Device Vendor ID = 0x10de (NVIDIA)
- Device Maximum **Compute Units = 80**
- Device Maximum Work Item Dimensions = 3
- Device Maximum Work Item Sizes = 1024 x 1024 x 64
- Device Maximum Work Group Size = 1024
- Device Maximum Clock Frequency = 1530 MHz

Device Extensions:
- cl_khr_global_int32_base_atomics
- cl_khr_global_int32_extended_atomics
- cl_khr_local_int32_base_atomics
- cl_khr_local_int32_extended_atomics
- cl_khr_fp64
- cl_khr_byte_addressable_store
- cl_khr_icd
- cl_khr_gl_sharing
- cl_nv_compiler_options
- cl_nv_device_attribute_query
- cl_nvPragma_unroll
- cl_nv_copy_opts
- cl_nv_create_buffer

For reference, rabbit’s graphics card has 15 Compute Units