GPU Configuration
Open-Source Mini-Clusters
CentOS8.3 Base OS, OpenHPC (v2.3)
xCAT/SLURM Edition for Linux* (x86_64)

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Revision 2.0

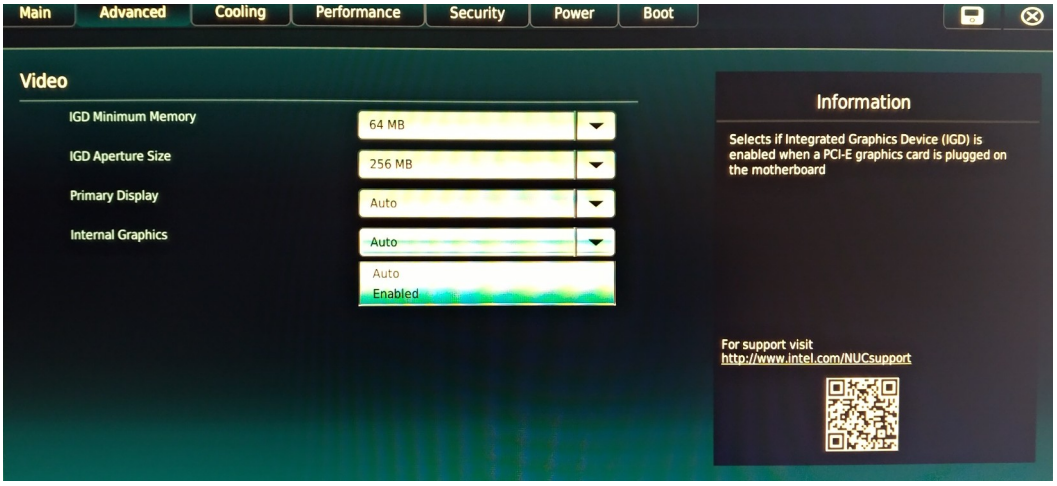
Table of Contents

Version	Description
v1.0	Initial draft. Moved Nvidia section from main cluster doc.
v2.0	Added AMD GPU
v2.1	Added AMD RPM installation, included page numbers

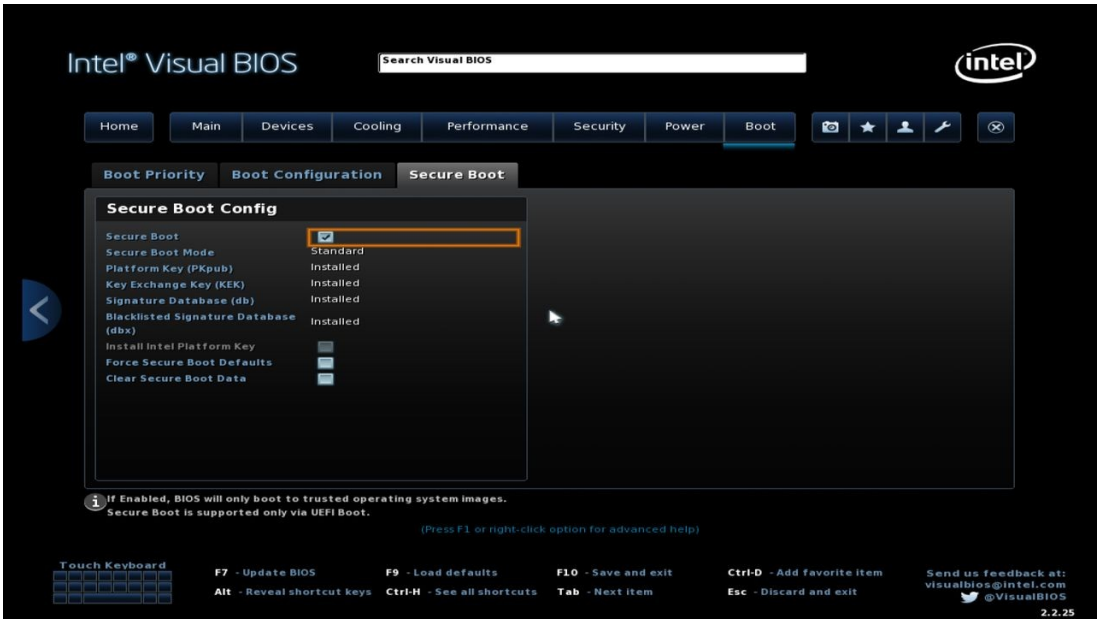
Introduction

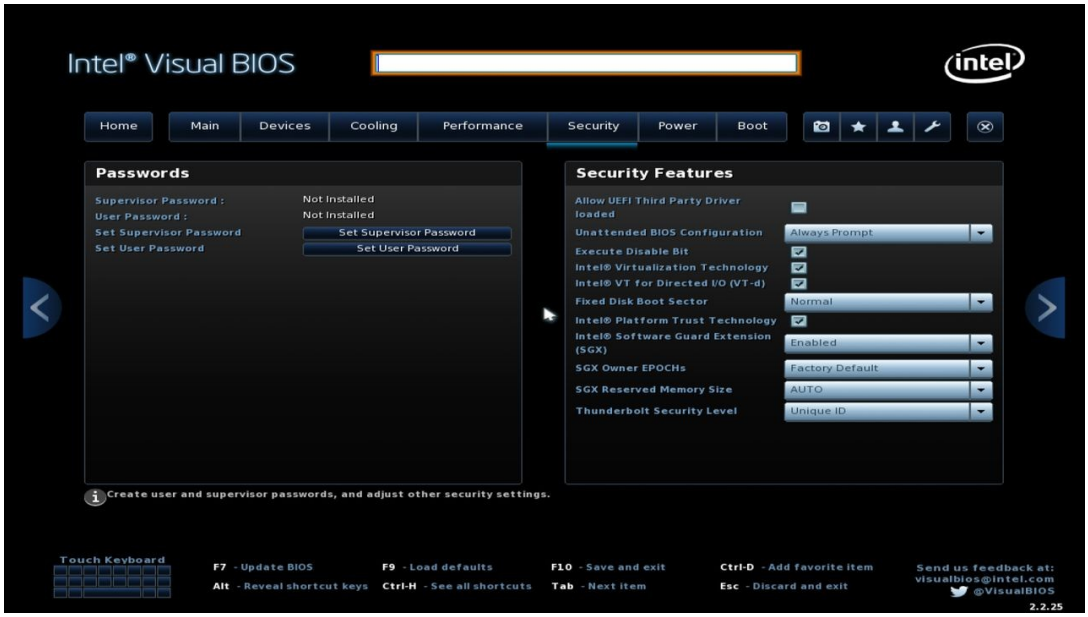
GPU installation and configuration is independent of any instructions in the top-level cluster setup document and does not require packages from the cluster setup. Instructions in this document can be performed before, or without, setting up the cluster environment.

If a discrete gpu is installed on the management node, the BIOS should be set to use internal graphics.



The device(s) with the GPU should have secure boot turned OFF in the BIOS, and select the BIOS option to allow 3rd party drivers during boot.





Nvidia Driver: Installation

To ensure compatibility with our hardware and cluster setup, we target specific versions of the Nvidia drivers and cuda that have been validated with hardware in this cluster environment, instead of installing the latest versions.

Before the driver can be installed, update the OS tools and libraries, add the required repository for driver tools we will need, and install the wget tool that will be needed for downloading certain files. It is possible that the update either added or changed kernel modules, which would require a reboot.

```
$> dnf clean all
$> dnf -y update
$> dnf -y --enablerepo=extras install epel-release
$> dnf -y install wget pciutils dkms
$> reboot
```

The Nvidia driver requires that kernel headers and kernel development packages for the current version of the kernel are installed before the driver is installed or rebuilt.

```
$> dnf -y --enablerepo=baseos install kernel-devel-$(uname -r) kernel-headers-$(uname -r)
```

Check the installed graphics devices.

```
$> lspci | grep VGA
```

There should be at least two listed devices: one is the integrated Intel graphics processor, and another entry should be the discrete GPU device.

Checking the installed graphics driver shows that the Nvidia driver is not being used.
The default graphics driver for linux is the open-source nouveau. Using the Nvidia driver requires

```
$> lshw -c video | grep 'configuration'
```

deactivating the nouveau driver and replacing with the proprietary Nvidia driver. One way to do this is with the Nvidia driver package.
Add the Nvidia repository and install the Nvidia driver package:

```
$> dnf config-manager --add-repo  \
      https://developer.download.nvidia.com/compute/cuda/repos/rhel8/x86_64/cuda-rhel8.repo
$> dnf -y module install nvidia-driver:470-dkms
```

A reboot is required for the driver to load. Before rebooting, confirm that the driver is installed. The dkms output should show the Nvidia driver, as well as the associated kernel version.

```
$> dkms status
$> reboot
```

After rebooting, verify that the Nvidia driver is installed and working.

```
$> nvidia-smi
```

The output should show information about the external GPU installed. Finally, install the cuda environment.

```
$> dnf -y install cuda-11-2
```

Low Bandwidth

If internet speed or low bandwidth is a problem, an alternate method for installing the Nvidia GPU driver is to download the cuda file and build it locally. The cuda package from the previous method is ~3.8GB, so downloading over the network would cause issues if internet speed is low.

```
$> wget -c http://developer.download.nvidia.com/compute/cuda/11.2.2/local_installers/
cuda_11.2.2_460.32.03_linux.run
$> sh ./cuda_11.2.2_460.32.03_linux.run
```

The local installer is a self-contained file with all components needed for cuda and the graphics driver. It only needs to be downloaded once. This method is limited to the listed versions: cuda version 11.2 and Nvidia driver version 460. Changing the versions requires downloading and executing a different file – for example:

```
$> wget -c https://developer.download.nvidia.com/compute/cuda/11.4.1/local_installers/
cuda_11.4.1_470.57.02_linux.run
```

Verify that the driver and cuda is installed.

```
$> dkms status
```

The output should show the Nvidia driver and kernel version.
A reboot is required for the changes to take effect after using the local installer.

```
$> reboot
```

After reboot, verify that the driver is active and cuda is installed.

```
$> lshw -c video | grep 'configuration'
$> nvidia-smi
$> /usr/local/cuda/bin/nvcc -V
```

If the driver is installed but not working then the nvidia-smi will fail.
The lshw command should now show that the nouveau driver is no longer being used, instead outputting '*Nvidia*' as the driver where the nouveau driver information was previously listed.

Nvidia Driver: Compute Node Installation

Instructions to install the Nvidia driver on compute nodes are similar to instructions for the head node.
Add the Nvidia repository and install the Nvidia driver package:

```
$> dnf --installroot=$CHROOT config-manager --add-repo  \
      https://developer.download.nvidia.com/compute/cuda/repos/rhel8/x86_64/cuda-rhel8.repo
$> dnf --installroot=$CHROOT -y module install nvidia-driver:470-dkms
```

Unlike the management node, it is not recommended to install cuda-11-2 into the diskless image. While this can be done by performing similar instructions listed in the section for the management node (`$> dnf--installroot=$CHROOT -y install cuda-11-2`), the cuda-11-2 package is large - 3.1GB - resulting in too much space used on the compute nodes in a smaller cluster environment. Instead, share the cuda folder from the head node across NFS network. To save space on the diskless compute nodes, the cuda folders on the head node will be shared with the compute nodes through NFS.

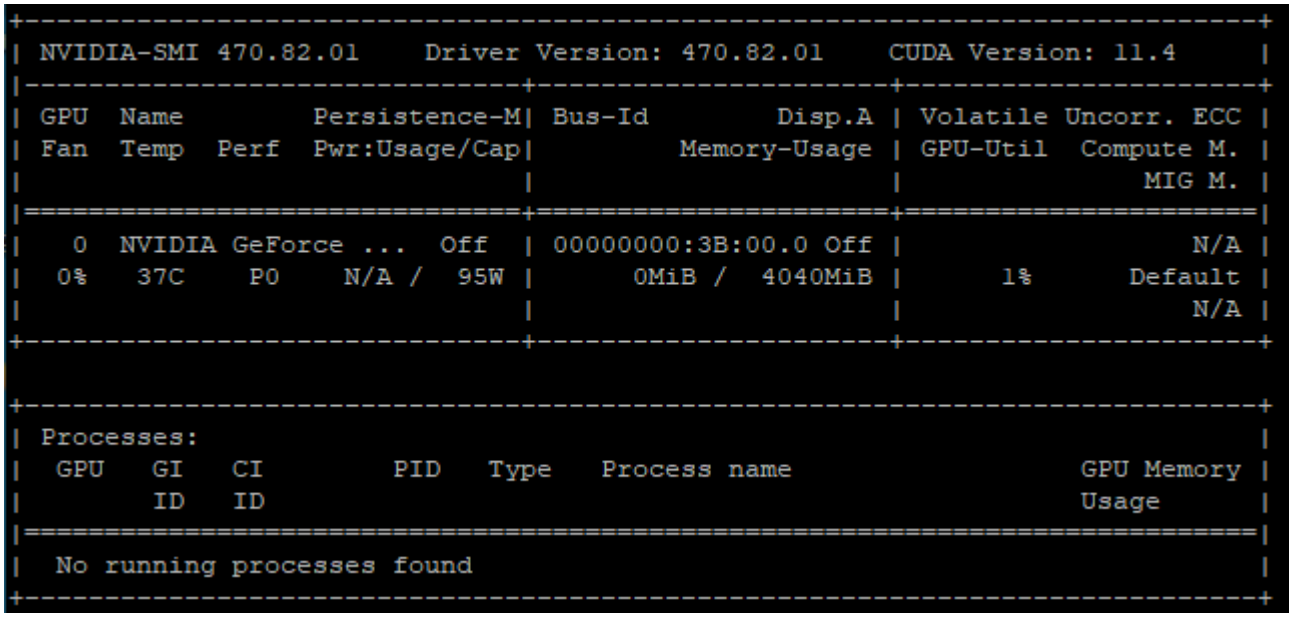
```
$> echo "10.10.1.10:/usr/local/cuda /usr/local/cuda nfs nfsvers=3,nodev,nosuid 0 0" >>
      $CHROOT/etc/fstab
$> echo "/usr/local/cuda *(ro,no_subtree_check,fsid=14)" >> /etc/exports
$> systemctl restart nfs-server
$> packimage centos8-x86_64-netboot-compute
$> pdsh -w c[1-2] reboot
```

Note the fsid=14. This number may need to be changed, depending on other folders shared. Check /etc/exports to see if FSID 14 has been reserved for a different folder. If it is, then change to the lowest number that is not being used.

Similar to the head node, check with nvidia-smi

```
$> nvidia-smi
```

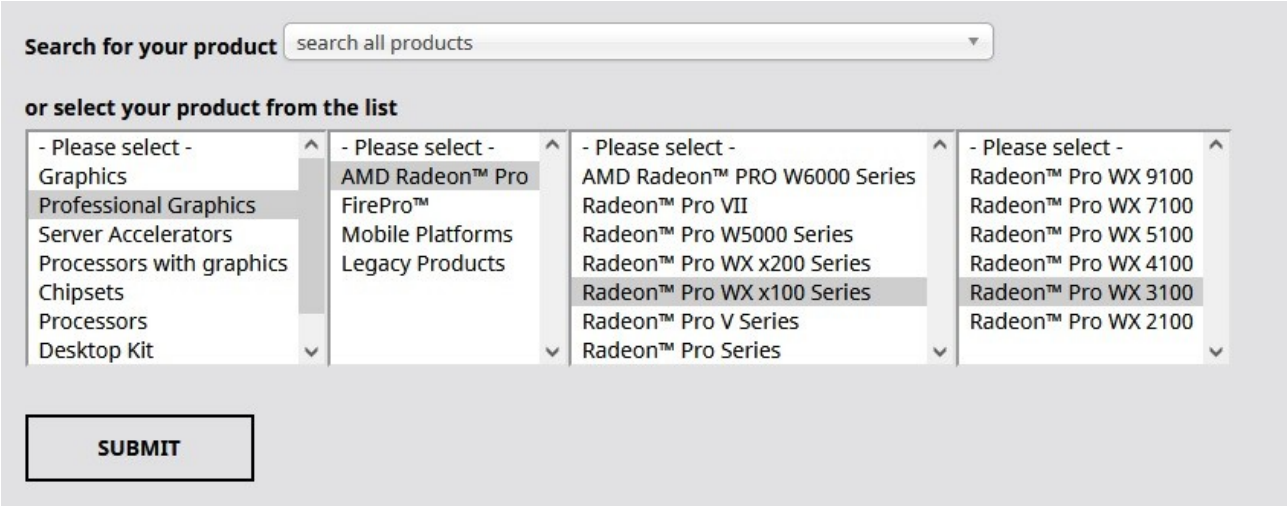
Sample output:



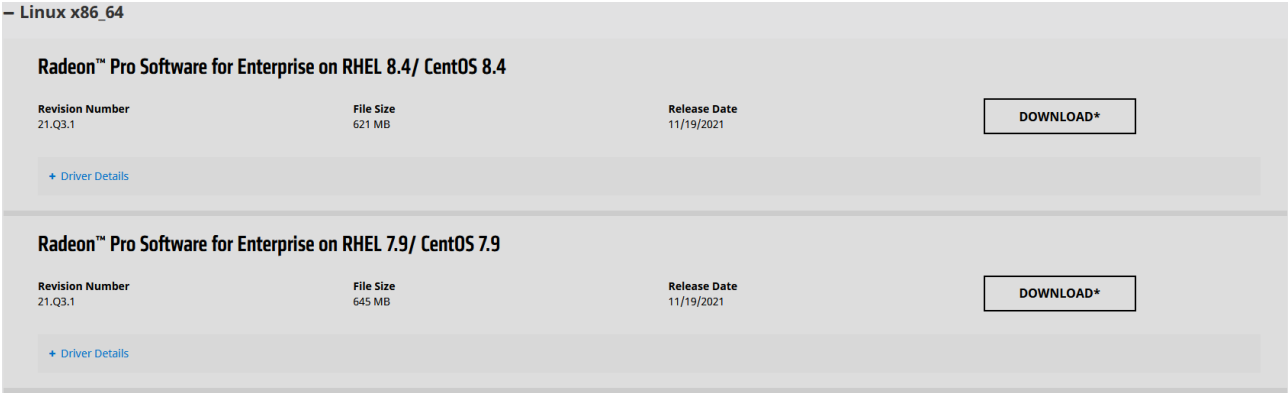
AMD Driver: Installation

These instructions assume only an AMD GPU on the node. The GPU used for this section is the AMD Radeon Pro WX3100. It is not recommended to have both Nvidia and AMD GPUs on the same node.

Unfortunately, AMD does not have a method to wget the driver tar package, therefore not allowing the driver tar package installation to be performed through scripting. Getting the tar package requires visiting their site (https://www.amd.com/en/support).



CentOS 8.3 is not available at the time of this writing, with v8.4 being the most viable version.



Untar the amdgpu-pro tar file and execute the installation script.

```
$> tar -xf amdgpu-pro-21.20-1292797-rhel-8.4.tar.xz
$> cd amdgpu-pro-21.20-1292797-rhel-8.4/
$> ./amdgpu-pro-install
```

One side effect of using 8.4 instead of 8.3 is that the version number may be different from the one used to validate in this document. After executing the script there may be a warning:

```
Complete!
WARNING: amdgpu dkms failed for running kernel
```

This can be ignored for the moment, since we are attempting to use drivers for CentOS8.4 while running CentOS8.3

An alternate method is to download the AMD repo directly from the command line instead of downloading the tar file from through the website. For example, the previous steps can be replaced with:

```
$> wget http://repo.radeon.com/amdgpu-install/latest/rhel/8.5/amdgpu-install-21.40.40500-1.noarch.rpm
$> dnf -y install amdgpu-install-21.40.2.40502-1.el7.noarch.rpm
```

The downside to this method is the lack if a generic 'latest' RPM file or folder. This requires the user to know the exact version numbers that are available – 21.40.40500-1 at the time of this writing.

Verify that the driver is installed and reboot.

```
$> dkms status
      amdgpu, 5.11.5.30-1292797.el8: added
$> reboot
```

The amdgpu-repo contains a tool called clinfo. This is a command-line program that prints the properties of all OpenCL devices on the system – meaning, it can be used to verify the GPU is available and ready for use.

```
$> dnf -y install clinfo-amdgpu-pro
$> /opt/amdgpu-pro/bin/clinfo
```

If an AMD GPU is present and the driver is successfully installed, the clinfo tool should show the following output:

```
Number of platforms:                               1
  Platform Profile:                                FULL_PROFILE
  Platform Version:                                OpenCL 2.0 AMD-APP (3261.0)
  Platform Name:                                   AMD Accelerated Parallel Processing
  Platform Vendor:                                 Advanced Micro Devices, Inc.
  Platform Extensions:                             cl_khr_icd cl_amd_event_callback


  Platform Name:                                   AMD Accelerated Parallel Processing
Number of devices:                                 0
```

AMD Driver: OpenCL

While it is possible to use the OpenCL package that comes with a CUDA installation, this section will show how to install the open source OpenCL package. These instructions assume a system that includes a single AMD GPU with the appropriate driver installed, as seen in the previous section.

To use the open source OpenCL package, enable the powertools repository to install the OpenCL API headers.

```
$> dnf config-manager --set-enabled powertools
$> dnf -y install ocl-icd opencl-headers
```

These packages prove libOpenCL and the /usr/include/CL header files that are used in OpenCL code. With these library and header files now on the system, OpenCL code can be used to verify a successful GPU installation using the code below, deviceInfo.c:

```
#include <stdio.h>
#include <stdlib.h>
#include <CL/cl.h>

int main(void)
{
  cl_int err;
  int i;
  cl_uint num_platforms;
  clGetPlatformIDs(0, NULL, &num_platforms);
  if (num_platforms == 0)
  {
    printf("\nNo platforms available!\n");
    return 0;
  }

  cl_platform_id platform[num_platforms];
  clGetPlatformIDs(num_platforms, platform, NULL);
  printf("\nOpenCL platforms:\n\n");

  for (i=0; i<num_platforms; i++)
  {
    cl_char string[10240] = {0};
    clGetPlatformInfo(platform[i], CL_PLATFORM_NAME, sizeof(string), &string, NULL);
    printf("%s\n",string);

    clGetPlatformInfo(platform[i], CL_PLATFORM_VENDOR, sizeof(string), &string, NULL);
    printf("Vendor: %s\n", string);

    clGetPlatformInfo(platform[i], CL_PLATFORM_VERSION, sizeof(string), &string, NULL);
    printf("Version: %s\n\n", string);
   }
   return 0;
}
```

Compile deviceInfo.c and execute with:

```
$> gcc deviceInfo.c -lOpenCL -o deviceInfo
$> ./deviceInfo
```

The program would produce the following output for a successfully installed AMD GPU:

```
OpenCL platforms:

AMD Accelerated Parallel Processing
Vendor: Advanced Micro Devices, Inc.
Version: OpenCL 2.0 AMD-APP (3261.0)
```