NVIDIA Data Center GPU Driver version
450.216.04 (Linux) / 453.94 (Windows)

Release Notes
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Chapter 1. Version Highlights

This section provides highlights of the NVIDIA Data Center GPU 450 Driver (version 450.216.04 Linux and 453.94 Windows).

For changes related to the 450 release of the NVIDIA display driver, review the file “NVIDIA_Changelog” available in the .run installer packages.

- Linux driver release date: 11/22/2022
- Windows driver release date: 11/22/2022

1.1. Software Versions

For this release, the software versions are listed below.

- CUDA Toolkit 11: 11.0.3
  Note that starting with CUDA 11, individual components of the toolkit are versioned independently. For a full list of the individual versioned components (such as nvcc, CUDA libraries, and so on), see the CUDA Toolkit Release Notes
- NVIDIA Data Center GPU Driver: 450.216.04 (Linux) / 453.94 (Windows)
- Fabric Manager: 450.216.04 (Use `nv-fabricmanager -v`)
- GPU VBIOS:
  - HGX A100 PG506
    - 92.00.45.00.03 SKU200 40GB air cooling [lidless]
    - 92.00.45.00.04 SKU202 40GB hybrid cooling [lidded]
    - 92.00.45.00.05 SKU210 80GB air cooling [lidless]
    - 92.00.45.00.06 SKU212 80GB hybrid cooling [lidded]
  - HGX A100 PG510
    - 92.00.81.00.01 SKU200 40GB air cooling [lidless]
    - 92.00.81.00.02 SKU202 40GB hybrid cooling [lidded]
    - 92.00.81.00.04 SKU210 80GB air cooling [lidless]
    - 92.00.81.00.05 SKU212 80GB hybrid cooling [lidded]
Version Highlights

- HGX A800 PG506
  - 92.00.A4.00.01 SKU215 80GB air cooling (lidless)
- HGX A800 PG510
  - 92.00.A4.00.05 SKU215 80GB air cooling (lidless)
- A100 PCIe P1001 SKU230
  - 92.00.90.00.04 [NVIDIA A100 PCIe]
- A800 PCIe P1001
  - 92.00.A4.00.0C 40 GB SKU203 PCIe
  - 92.00.A4.00.0D 80 GB SKU235 PCIe
- NVSwitch VBIOS: 92.10.14.00.01
- NVFlash: 5.791

Due to a revision lock between the VBIOS and driver, VBIOS versions >= 92.00.18.00.00 must use corresponding drivers >= 450.36.01. Older VBIOS versions will work with newer drivers.

For more information on getting started with the NVIDIA Fabric Manager on NVSwitch-based systems (for example, HGX A100), refer to the Fabric Manager User Guide.

1.2. Fixed Issues

- CLVC - Closed Loop Voltage Controller - is a controller that periodically monitors and corrects for voltage errors. Any error (+/-) is corrected by applying a appropriate voltage offset to the VOLT/regulator. Features like droopy, thermal slowdown can cause voltage set in HW to deviate from the SW requested value. In such usecases, CLVC should NOT correct for it as its not an “error” but sideeffect of droopy/slowdown. Evaluation loop of CLVC queries and calculates how long the feature like droopy/slowdown were engaged in order to check if such an event was active after the previous cycle. If droopy/slowdown was engaged we poison the sample instead of correcting the for error.

- CLFC - Closed Loop Frequency Controller - is equivalent to CLVC, however CLFC corrects for frequency errors not voltage errors. CLFC is enabled on TU10x onwards (except ampere). CLVC is enabled on GA100 onwards.

In the earlier CLFC bug, the counter that queries THERM task for residency/engaged count time was using 32-bit counter which overflows a lot quicker than 64-bit counters. As part of the fix, engaged timers were updated to use 64-bit counter with special attention to prevent overflows.

In the CLVC bug, whenever the engagedtime differed more than the evaluation time threshold, PMU was halted assuming it was an error condition. Instead of halting the PMU, we discard the sample by poisoning it.

Both the bugs are in two related but separate features that use droopy/slowdown. CLFC bug updated the infra used to compute the engaged/elapsed timers from 32-bit to 64-bit. CLVC bug updated how the error case is handled in certain usecases.
In the L1C submodule when the clock is gated, there is a corner case where the BLCG controller was not woken up from sleep state when an external submodule wants to use L1C. This was fixed by Switching the PROD value to disable L1C BLCG will not cause the hang in the chip until some other event wakes up the BLCG FSM.

An issue which caused a kernel panic on A100 when using both MIG and DCGM is resolved.

The Access Write Protect Mode (opcode 17h) SMBPBI command resulted in an fatal access violation by reading a GPU register that is protected on certain GV100 configurations. The error is fatal for the SMBPBI server and results in a driver crash. The fix adds logic to the SMBPBI server to detect if the offending GPU register is privileged and disables opcode 17h on these configurations.

Resolved an issue that caused the MPS server to hang when running applications compiled under different version of gcc.

### 1.3. Known Issues

#### General

- The GPU driver build system might not pick the `Module.symvers` file, produced when building the `ofa_kernel` module from MLNX_OFED, from the right subdirectory. Because of that, `nvidia_peermem.ko` does not have the right kernel symbol versions for the APIs exported by the IB core driver, and therefore it does not load correctly. That happens when using MLNX_OFED 5.5 or newer on a Linux Arm64 or ppc64le platform.

To work around this issue, perform the following:

1. Verify that `nvidia_peermem.ko` does not load correctly.
2. Uninstall old MLNX_OFED if one was installed.
3. Manually remove `/usr/src/ofa_kernel/default` if one exists.
4. Install MLNX_OFED 5.5 or newer.
5. Manually create a soft link:

   ```bash
   /usr/src/ofa_kernel/default -> /usr/src/ofa_kernel/$(uname -m)/$(uname -r)
   ```

6. Reinstall the GPU driver.

- Combining A800 and A100 SXM modules in a single server is not currently supported with this driver version.

- Combining A800 and A100 PCIe with NVLink is not fully tested.

- There is a known issue with installing the Linux driver where installing the driver interferes with the `ipmitool`.

- When installing a driver on SLES15 or openSUSE15 that previously had an R515 driver installed, users need to run the following command afterwards to finalize the installation:

  ```bash
  sudo zypper install --force nvidia-gfxG05-kmp-default
  ```

Without doing this, users may see the kernel objects as missing.
By default, Fabric Manager runs as a systemd service. If using `DAEMONIZE=0` in the Fabric Manager configuration file, then the following steps may be required.

1. Disable FM service from auto starting. (`systemctl disable nvidia-fabricmanager`)
2. Once the system is booted, manually start FM process. (`/usr/bin/nv-fabricmanager -c /usr/share/nvidia/nvswitch/fabricmanager.cfg`). Note, since the process is not a daemon, the SSH/Shell prompt will not be returned (use another SSH shell for other activities or run FM as a background task).

There is a known issue with cross-socket GPU to GPU memory consistency that is currently under investigation

**GPU Performance Counters**

The use of developer tools from NVIDIA that access various performance counters requires administrator privileges. See this [note](#) for more details. For example, reading NVLink utilization metrics from `nvidia-smi` (`nvidia-smi nvlink -g 0`) would require administrator privileges.

**NoScanout Mode**

NoScanout mode is no longer supported on NVIDIA Data Center GPU products. If NoScanout mode was previously used, then the following line in the “screen” section of `/etc/X11/xorg.conf` should be removed to ensure that X server starts on data center products:

```
Option "UseDisplayDevice" "None"
```

NVIDIA Data Center GPU products now support one display of up to 4K resolution.

**Unified Memory Support**

CUDA and unified memory is not supported when used with Linux power management states S3/S4.

**IMPU FRU for Volta GPUs**

The driver does not support the IPMI FRU multi-record information structure for NVLink. See the Design Guide for Tesla P100 and Tesla V100-SXM2 for more information.

**Experimental OpenCL Features**

Select features in OpenCL 2.0 are available in the driver for evaluation purposes only. The following are the features as well as a description of known issues with these features in the driver:

- **Device side enqueue**
  - The current implementation is limited to 64-bit platforms only.
OpenCL 2.0 allows kernels to be enqueued with `global_work_size` larger than the compute capability of the NVIDIA GPU. The current implementation supports only combinations of `global_work_size` and `local_work_size` that are within the compute capability of the NVIDIA GPU. The maximum supported CUDA grid and block size of NVIDIA GPUs is available at http://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html#computecapabilities. For a given grid dimension, the `global_work_size` can be determined by CUDA grid size x CUDA block size.

For executing kernels (whether from the host or the device), OpenCL 2.0 supports non-uniform ND-ranges where `global_work_size` does not need to be divisible by the `local_work_size`. This capability is not yet supported in the NVIDIA driver, and therefore not supported for device side kernel enqueues.

**Shared virtual memory**

- The current implementation of shared virtual memory is limited to 64-bit platforms only.
Chapter 2. Virtualization

To make use of GPU passthrough with virtual machines running Linux, the hardware platform must support the following features:

- A CPU with hardware-assisted instruction set virtualization: Intel VT-x or AMD-V.
- Platform support for I/O DMA remapping.
- On Intel platforms the DMA remapper technology is called Intel VT-d.
- On AMD platforms it is called AMD IOMMU.

Support for these features varies by processor family, product, and system, and should be verified at the manufacturer’s website.

**Supported Hypervisors**

The following hypervisors are supported:

<table>
<thead>
<tr>
<th>Hypervisor</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrix XenServer</td>
<td>Version 6.0 and later</td>
</tr>
<tr>
<td>VMware vSphere [ESX / ESXi]</td>
<td>Version 5.1 and later.</td>
</tr>
<tr>
<td>Red Hat KVM</td>
<td>Red Hat Enterprise Linux 7 with KVM</td>
</tr>
<tr>
<td>Microsoft Hyper-V</td>
<td>Windows Server 2016 Hyper-V Generation 2</td>
</tr>
<tr>
<td></td>
<td>Windows Server 2012 R2 Hyper-V</td>
</tr>
</tbody>
</table>

Tesla products now support one display of up to 4K resolution.

**Supported Graphics Cards**

The following GPUs are supported for device passthrough:

<table>
<thead>
<tr>
<th>GPU Family</th>
<th>Boards Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA Ampere GPU Architecture</td>
<td>NVIDIA A100, A800</td>
</tr>
<tr>
<td>Turing</td>
<td>NVIDIA T4</td>
</tr>
<tr>
<td>Volta</td>
<td>NVIDIA V100</td>
</tr>
<tr>
<td>GPU Family</td>
<td>Boards Supported</td>
</tr>
<tr>
<td>------------</td>
<td>------------------</td>
</tr>
</tbody>
</table>
| Pascal     | Quadro: P2000, P4000, P5000, P6000, GP100  
             | Tesla: P100, P40, P4 |
| Maxwell    | Quadro: K2200, M2000, M4000, M5000, M6000, M6000 24GB  
             | Tesla: M60, M40, M6, M4 |
| Kepler     | Quadro: K2000, K4000, K4200, K5000, K5200, K6000  
             | Tesla: K520, K80  
             | Tesla: K10, K20, K20x, K20Xm, K20c, K20s, K40m, K40c, K40s, K40st, K40t, K80, K520 |
Chapter 3. Hardware and Software Support

Support for these features varies by processor family, product, and system, and should be verified at the manufacturer’s website.

Supported Operating Systems for NVIDIA Data Center GPUs

The Release 450 driver is supported on the following operating systems:

- Windows x86_64 operating systems:
  - Microsoft Windows® Server 2019
  - Microsoft Windows® Server 2016
  - Microsoft Windows® 10

- The following table summarizes the supported Linux 64-bit distributions. For a complete list of distributions, kernel versions supported, see the CUDA Linux System Requirements documentation.

<table>
<thead>
<tr>
<th>Distribution</th>
<th>x86_64</th>
<th>POWER</th>
<th>Arm64 Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>OpenSUSE Leap 15.x (where y &lt;= 4)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Red Hat Enterprise Linux 8.y (where y &lt;= 6)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Red Hat Enterprise Linux / CentOS 7.y (where y &lt;= 9)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Rocky Linux 8.x (where x&lt;=6)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>SUSE Linux Enterprise Server 15.x (where y &lt;= 4)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ubuntu 20.04.x LTS (where y &lt;= 5)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Supported Operating Systems and CPU Configurations for NVIDIA HGX A100 and NVIDIA HGX A800

The Release 450 driver is validated with HGX A100 and HGX A800 on the following operating systems and CPU configurations:

- **Linux 64-bit distributions:**
  - Red Hat Enterprise Linux 8.6 (in 4/8/16-GPU configurations)
  - CentOS Linux 7.9 (in 4/8/16-GPU configurations)
  - Ubuntu 18.04.6 LTS (in 4/8/16-GPU configurations)
  - SUSE SLES 15.4 (in 4/8/16-GPU configurations)

- **Windows 64-bit distributions:**
  - Windows Server 2019 (in 1/2/4/8-GPU configurations; 16-GPU configurations are currently not supported)

  Windows is supported only in shared NVSwitch virtualization configurations.

- **CPU Configurations:**
  - AMD Rome in PCIe Gen4 mode
  - Intel Skylake/Cascade Lake (4-socket) in PCIe Gen3 mode

Supported Virtualization Configurations

The Release 450 driver is validated with HGX A100 on the following configurations:

- **Passthrough (full visibility of GPUs and NVSwitches to guest VMs):**
  - 8-GPU configurations with Ubuntu 18.04.5 LTS

- **Shared NVSwitch (guest VMs only have visibility of GPUs and full NVLink bandwidth between GPUs in the same guest VM):**
  - 1/2/4/8/16-GPU configurations with Ubuntu 18.04.5 LTS
  - 1/2/4/8-GPU configurations with Windows Server 2019

API Support

This release supports the following APIs:

- NVIDIA® CUDA® 11.0 for NVIDIA® Kepler™, Maxwell™, Pascal™, Volta™, Turing™ and NVIDIA Ampere architecture GPUs
- OpenGL® 4.5
- Vulkan® 1.1
- DirectX 11
- DirectX 12 (Windows 10)
- Open Computing Language (OpenCL™ software) 1.2

Note that for using graphics APIs on Windows (such as OpenGL, Vulkan, DirectX 11, and DirectX 12) or any WDDM 2.0+ based functionality on data center GPUs, vGPU is required. See the vGPU documentation for more information.

**Supported NVIDIA Data Center GPUs**

The NVIDIA Data Center GPU driver package is designed for systems that have one or more Tesla products installed. This release of the driver supports CUDA C/C++ applications and libraries that rely on the CUDA C Runtime and/or CUDA Driver API.

<table>
<thead>
<tr>
<th>NVIDIA Server Platforms</th>
<th>Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA HGX A800</td>
<td>A800 and NVSwitch</td>
</tr>
<tr>
<td>NVIDIA HGX A100</td>
<td>A100 and NVSwitch</td>
</tr>
<tr>
<td>NVIDIA HGX-2</td>
<td>V100 and NVSwitch</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RTX-Series Products</th>
<th>GPU Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quadro RTX 8000</td>
<td>NVIDIA Turing</td>
</tr>
<tr>
<td>Quadro RTX 6000</td>
<td>NVIDIA Turing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A-Series Products</th>
<th>GPU Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA A800</td>
<td>NVIDIA Ampere</td>
</tr>
<tr>
<td>NVIDIA A100</td>
<td>NVIDIA Ampere</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T-Series Products</th>
<th>GPU Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA T4</td>
<td>NVIDIA Turing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V-Series Products</th>
<th>GPU Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA V100</td>
<td>NVIDIA Volta</td>
</tr>
<tr>
<td><strong>Tesla P-Series Products</strong></td>
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</tr>
<tr>
<td><strong>Product</strong></td>
<td><strong>GPU Architecture</strong></td>
</tr>
<tr>
<td>NVIDIA Tesla P100</td>
<td>NVIDIA Pascal</td>
</tr>
<tr>
<td>NVIDIA Tesla P40</td>
<td>NVIDIA Pascal</td>
</tr>
<tr>
<td>NVIDIA Tesla P4</td>
<td>NVIDIA Pascal</td>
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</tbody>
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<tr>
<th><strong>Tesla K-Series Products</strong></th>
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<tbody>
<tr>
<td><strong>Product</strong></td>
<td><strong>GPU Architecture</strong></td>
</tr>
<tr>
<td>NVIDIA Tesla K520</td>
<td>NVIDIA Kepler</td>
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<tr>
<td>NVIDIA Tesla K80</td>
<td>NVIDIA Kepler</td>
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<table>
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<tr>
<th><strong>Tesla M-Class Products</strong></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td><strong>GPU Architecture</strong></td>
</tr>
<tr>
<td>NVIDIA Tesla M60</td>
<td>Maxwell</td>
</tr>
<tr>
<td>NVIDIA Tesla M40 24 GB</td>
<td>Maxwell</td>
</tr>
<tr>
<td>NVIDIA Tesla M40</td>
<td>Maxwell</td>
</tr>
<tr>
<td>NVIDIA Tesla M6</td>
<td>Maxwell</td>
</tr>
<tr>
<td>NVIDIA Tesla M4</td>
<td>Maxwell</td>
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</tbody>
</table>
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