CUDA on WSL User Guide

User Guide

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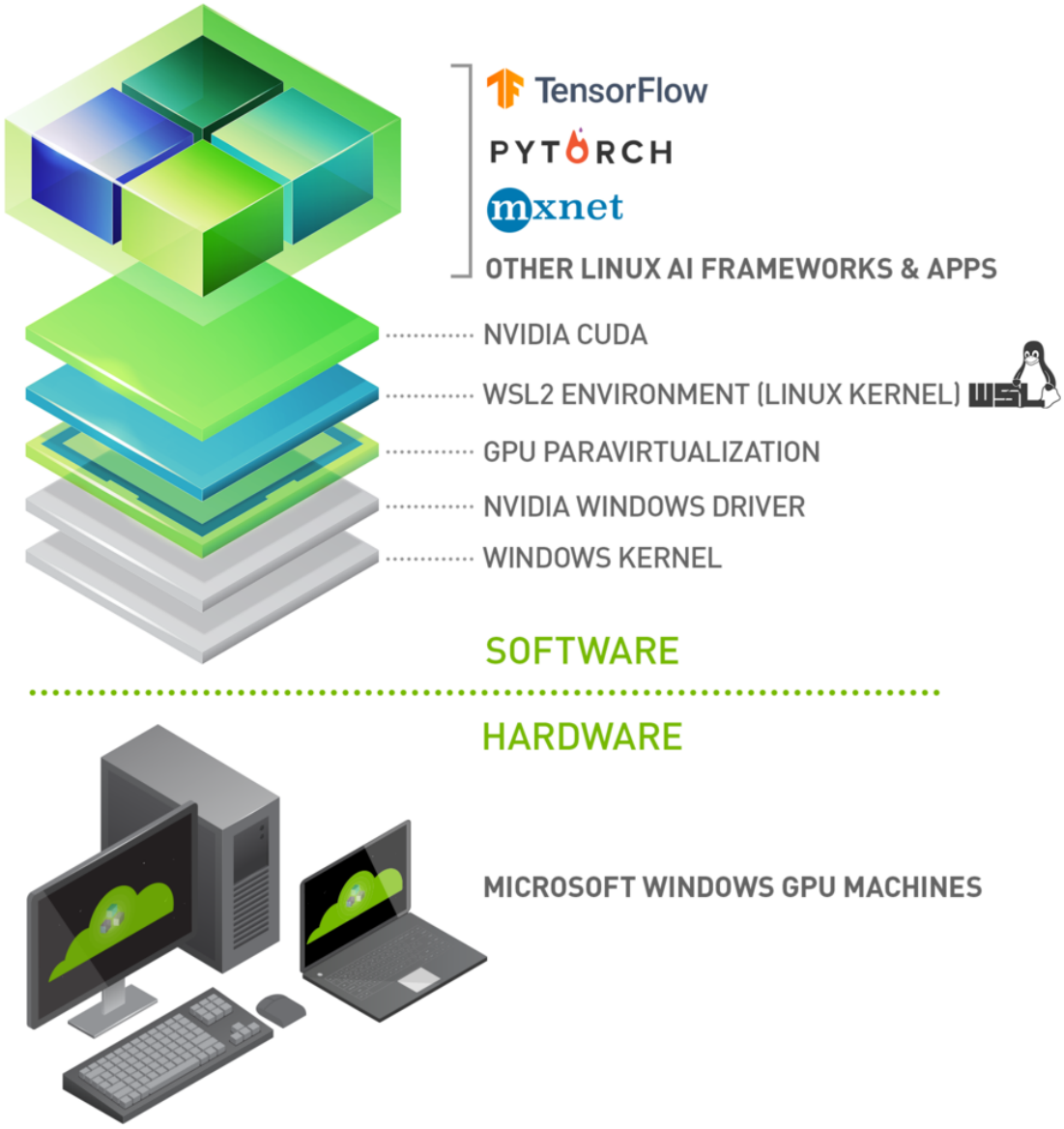
Table of Contents

Chapter 1. Introduction

Windows Subsystem for Linux (WSL) is a Windows 10 feature that enables users to run native Linux command-line tools directly on Windows. WSL is a containerized environment within which users can run Linux native applications from the command line of the Windows 10 shell without requiring the complexity of a dual boot environment. Internally, WSL is tightly integrated with the Microsoft Windows operating system, which allows it to run Linux applications alongside traditional Windows desktop and modern store apps.

Figure 1. CUDA on WSL Overview



With WSL 2 and GPU paravirtualization technology, Microsoft enables developers to run GPU accelerated applications on Windows. NVIDIA GPU acceleration will be available with official support on Pascal and later GeForce and Quadro GPUs in Windows Device Driver Model. However, we recommend using Turing or newer architectures for better performance.

The following document describes a workflow for getting started with running CUDA applications or containers in a WSL 2 environment.

Chapter 2. Getting Started

Getting started with running CUDA on WSL requires you to complete these steps in order:

1. WSL 2 System Requirements
2. Installing Microsoft Windows Insider Preview OS Builds
3. Installing NVIDIA Drivers for CUDA. DirectX, and DirectML Support
4. Installing WSL 2 and Setting up a Linux Development Environment

2.1. WSL 2 System Requirements

- Ensure you are registered on Windows Insider Program and subscribing to the Dev Channel and OS build is 20145 or later. We recommend at least OS 21390 or higher for latest features and performance updates.
- Windows 11 is supported. Refer to Windows 11 system requirements.
- Ensure the WSL Kernel installed is the latest version or at least 4.19.121+. Once again we recommend 5.10.16.3 or later for better performance.
- WSL2 GPU acceleration will be available on Pascal and later GPU architecture on both GeForce and Quadro product SKUs in WDDM mode. It will not be available on Quadro GPUs in TCC mode or Tesla GPUs yet.

2.2. Installing Microsoft Windows Insider Preview OS Builds

- Register for the Windows Insider Program and choose dev channel as your flighting channel (previously fast rings).
- Install the latest build from the Dev Channel. Review WSL 2 system requirements for minimum requirements and our recommendations. You can check your build version number by running `winver` via the Run command.

2.3. Installing NVIDIA Drivers for CUDA. DirectX, and DirectML Support

- Download the NVIDIA Driver from the download section on the CUDA on WSL page. Choose the appropriate driver depending on the type of NVIDIA GPU in your system - GeForce and Quadro.
- Install the driver using the executable on the Windows machine. The Windows Display Driver will install both the regular driver components for native Windows and for WSL support. **This is the only driver you need to install.**

  CUDA support enables GPU accelerated computing for data science, machine learning and inference solutions. DirectX support enables graphics on WSL2 by supporting DX12 APIs. TensorFlow with DirectML support on WSL2 will get NV GPU hardware acceleration for training and inference workloads.

  For some helpful examples, see https://docs.microsoft.com/en-us/windows/win32/direct3d12/gpu-tensorflow-wsl.

Note: This is the only driver you need to install. Do not install any Linux display driver in WSL.CUDA, DirectML and DirectX support will be available with this driver. No additional drivers are needed for WSL2.

2.4. Installing WSL 2 and Setting up a Linux Development Environment

1. Install WSL 2 by following the instructions in the Microsoft documentation available here.
2. Ensure you have the latest or at least the minimum required WSL kernel installed. Please review the system requirements and troubleshooting sections in case of issues.
3. Launch the Linux distribution and make sure it runs in WSL 2 mode using the following command:

```
$ wsl.exe --list -v command
```

2.5. Setting up CUDA Toolkit on WSL 2

It is recommended to use the Linux package manager to install the CUDA for the Linux distributions supported under WSL 2. CUDA Toolkit available for Linux distributions can be used for WSL2 as well, but these toolkits come packaged with the NVIDIA GPU Linux driver which must not be installed. So care must be taken not to override the WSL2 native drivers already installed in the system.

In order to ease the installation and not to accidentally override the Windows native WSL2 driver already installed in the system, we have created a separate package under the category WSL-Ubuntu here.

Follow the instructions below to install the CUDA Toolkit from the WSL-Ubuntu package on Ubuntu.

```
$ wget https://developer.download.nvidia.com/compute/cuda/repos/wsl-ubuntu/x86_64/
cuda-wsl-ubuntu.pin
$ sudo mv cuda-wsl-ubuntu.pin /etc/apt/preferences.d/cuda-repository-pin-600
$ wget https://developer.download.nvidia.com/compute/cuda/11.4.0/local_installers/
cuda-repo-wsl-ubuntu-11-4-local_11.4.0-1_amd64.deb
$ sudo dpkg -i cuda-repo-wsl-ubuntu-11-4-local_11.4.0-1_amd64.deb
$ sudo apt-key add /var/cuda-repo-wsl-ubuntu-11-4-local/7fa2af80.pub
$ sudo apt-get update
$ sudo apt-get -y install cuda
```

Please note we are installing CUDA because the WSL-ubuntu package only has the CUDA toolkit.

But if you are installing CUDA toolkit from our regular package, note that for WSL 2, you should use the `cuda-toolkit-<version>` meta-package to avoid installing the NVIDIA driver that is typically bundled with the toolkit.

```
$ wget https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2004/x86_64/
cuda-ubuntu2004.pin
$ sudo mv cuda-ubuntu2004.pin /etc/apt/preferences.d/cuda-repository-pin-600
$ wget https://developer.download.nvidia.com/compute/cuda/11.4.0/local_installers/
cuda-repo-ubuntu2004-11-4-local_11.4.0-470.42.01-1_amd64.deb
$ sudo dpkg -i cuda-repo-ubuntu2004-11-4-local_11.4.0-470.42.01-1_amd64.deb
$ sudo apt-key add /var/cuda-repo-ubuntu2004-11-4-local/7fa2af80.pub
$ sudo apt-get update
```

Do not choose the “cuda”, “cuda-11-0”, or “cuda-drivers” meta-packages under WSL 2 if you are installing the regular CUDA toolkit as these packages will result in an attempt to install the Linux NVIDIA driver under WSL 2.

```
$ apt-get install -y cuda-toolkit-11-4
```

2.6. Running CUDA Applications

Just run your CUDA app as you would run it under Linux! Once the driver is installed there is nothing more to do to run existing CUDA applications that were built on Linux.

A snippet of running the BlackScholes Linux application from the CUDA samples is shown below.

Build the CUDA samples available under `/usr/local/cuda/samples` from your installation of the CUDA Toolkit in the previous section. The BlackScholes application is located under `/usr/local/cuda/samples/4_Finance/BlackScholes`. Alternatively, you can transfer a binary built on Linux to WSL 2!

```
C:\> wsl
To run a command as administrator (user “root”), use “sudo <command>”.
See “man sudo_root” for details.
```

```
$ cd /usr/local/cuda-11.4/samples/4_Finance/BlackScholes
$ make BlackScholes
$ ./BlackScholes

Initializing data...
...allocating CPU memory for options.
...allocating GPU memory for options.
...generating input data in CPU mem.
...copying input data to GPU mem.
Data init done.

Executing Black-Scholes GPU kernel (131072 iterations)...
Options count             : 8000000
BlackScholesGPU() time    : 0.207633 msec
Effective memory bandwidth: 385.295561 GB/s
Gigaoptions per second    : 38.529556
```

2.7. Running CUDA Containers

2.7.1. Setup

This chapter describes the workflow for setting up the NVIDIA Container Toolkit in preparation for running GPU accelerated containers.

2.7.2. Install Docker

Use the Docker installation script to install Docker for your choice of WSL 2 Linux distribution. Note that NVIDIA Container Toolkit has not yet been validated with Docker Desktop WSL 2 backend.

Note: For this release, install the standard Docker-CE for Linux distributions.

```
$ curl https://get.docker.com | sh
```

2.7.3. Install NVIDIA Container Toolkit

Now install the NVIDIA Container Toolkit (previously known as nvidia-docker2). WSL 2 support is available starting with `nvidia-docker2` v2.3 and the underlying runtime library (`libnvidia-container` >= 1.2.0-rc.1).

For brevity, the installation instructions provided here are for Ubuntu.

Setup the `stable` and `experimental` repositories and the GPG key. The changes to the runtime to support WSL 2 are available in the experimental repository.

```
$ distribution=$(. /etc/os-release;echo $ID$VERSION_ID)

$ curl -s -L https://nvidia.github.io/nvidia-docker/gpgkey | sudo apt-key add -
```

```
$ curl -s -L https://nvidia.github.io/nvidia-docker/$distribution/nvidia-docker.list
 | sudo tee /etc/apt/sources.list.d/nvidia-docker.list

$ curl -s -L https://nvidia.github.io/libnvidia-container/experimental/
$distribution/libnvidia-container-experimental.list | sudo tee /etc/apt/
sources.list.d/libnvidia-container-experimental.list
```

Install the NVIDIA runtime packages (and their dependencies) after updating the package listing.

```
$ sudo apt-get update

$ sudo apt-get install -y nvidia-docker2
```

Open a separate WSL 2 window and start the Docker daemon again using the following commands to complete the installation.

```
$ sudo service docker stop

$ sudo service docker start
```

2.7.4. Running Simple CUDA Containers

In this example, let's run an N-body simulation CUDA sample. This example has already been containerized and available from NGC.

```
$ docker run --gpus all nvcr.io/nvidia/k8s/cuda-sample:nbody nbody -gpu -benchmark
```

From the console, you should see output as shown below.

```
$ docker run --gpus all nvcr.io/nvidia/k8s/cuda-sample:nbody nbody -gpu -benchmark
Run "nbody -benchmark [-numbodies=<numBodies>]" to measure performance.
        -fullscreen       (run n-body simulation in fullscreen mode)
        -fp64             (use double precision floating point values for
 simulation)
        -hostmem          (stores simulation data in host memory)
        -benchmark        (run benchmark to measure performance)
        -numbodies=<N>    (number of bodies (>= 1) to run in simulation)
        -device=<d>       (where d=0,1,2.... for the CUDA device to use)
        -numdevices=<i>   (where i=(number of CUDA devices > 0) to use for
 simulation)
        -compare          (compares simulation results running once on the default
 GPU and once on the CPU)
        -cpu              (run n-body simulation on the CPU)
        -tipsy=<file.bin> (load a tipsy model file for simulation)

NOTE: The CUDA Samples are not meant for performance measurements. Results may vary
 when GPU Boost is enabled.

> Windowed mode
> Simulation data stored in video memory
> Single precision floating point simulation
> 1 Devices used for simulation
```

```
GPU Device 0: "Turing" with compute capability 7.5

> Compute 7.5 CUDA device: [NVIDIA GeForce RTX 2080]
47104 bodies, total time for 10 iterations: 68.445 ms
= 324.169 billion interactions per second
= 6483.371 single-precision GFLOP/s at 20 flops per interaction
```

2.7.5. Jupyter Notebooks

In this example, let's run a Jupyter notebook.

```
$ docker run -it --gpus all -p 8888:8888 tensorflow/tensorflow:latest-gpu-py3-
jupyter
```

After the container starts, you can see the following output on the console.

```
________                                    _______________
___  __/__________________________________ ____/__  /________      __
__  /  _  _ \_  __ \_  ___/  __ \_  ___/_  /_   __  /_  __ \_ | /| / /
_  /   /  __/  / / /(__  )/ /_/ /  /   _  __/   _  / / /_/ /_ |/ |/ /
/_/    \___//_/ /_//____/ \____//_/    /_/      /_/  \____/____/|__/

WARNING: You are running this container as root, which can cause new files in
mounted volumes to be created as the root user on your host machine.

To avoid this, run the container by specifying your user's userid:

$ docker run -u $(id -u):$(id -g) args...

[I 04:00:11.167 NotebookApp] Writing notebook server cookie secret to /root/.local/
share/jupyter/runtime/notebook_cookie_secret
jupyter_http_over_ws extension initialized. Listening on /http_over_websocket
[I 04:00:11.447 NotebookApp] Serving notebooks from local directory: /tf
[I 04:00:11.447 NotebookApp] The Jupyter Notebook is running at:
[I 04:00:11.447 NotebookApp] http://72b6a6dfac02:8888/?
token=6f8af846634535243512de1c0b5721e6350d7dbdbd5e4a1b
[I 04:00:11.447 NotebookApp]  or http://127.0.0.1:8888/?
token=6f8af846634535243512de1c0b5721e6350d7dbdbd5e4a1b
[I 04:00:11.447 NotebookApp] Use Control-C to stop this server and shut down all
 kernels (twice to skip confirmation).
[C 04:00:11.451 NotebookApp]

    To access the notebook, open this file in a browser:
        file:///root/.local/share/jupyter/runtime/nbserver-1-open.html
    Or copy and paste one of these URLs:
        http://72b6a6dfac02:8888/?
token=6f8af846634535243512de1c0b5721e6350d7dbdbd5e4a1b
     or http://127.0.0.1:8888/?
token=6f8af846634535243512de1c0b5721e6350d7dbdbd5e4a1b
```

After the URL is available from the console output, input the URL into your browser to start developing with the Jupyter notebook. Ensure that you replace `127.0.0.1` with `localhost` in the URL when connecting to the Jupyter notebook from the browser. You should be able to view the TensorFlow tutorial in your browser. Choose any of the tutorials for this example.

Navigate to the **Cell** menu and select the **Run All** item, then check the log within the Jupyter notebook WSL 2 container to see the work accelerated by the GPU of your Windows PC.

```
...
[I 16:00:00.150 NotebookApp] 302 GET /?
token=1fc498fd08ea697cd1a01b5061bcc1b381254eeb4f768d5d (172.17.0.1) 0.51ms
[I 16:00:07.509 NotebookApp] Writing notebook-signing key to /root/.local/share/
jupyter/notebook_secret
[W 16:00:07.511 NotebookApp] Notebook tensorflow-tutorials/classification.ipynb is
 not trusted

[I 16:00:08.281 NotebookApp] Kernel started: 8fcadc98-b40e-41ee-8ce2-003afd444678
2021-07-07 16:00:14.343853: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libnvinfer.so.6
2021-07-07 16:00:14.357695: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libnvinfer_plugin.so.6
2021-07-07 16:00:25.573058: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libcuda.so.1
2021-07-07 16:00:25.736913: E tensorflow/stream_executor/cuda/
cuda_gpu_executor.cc:967] could not open file to read NUMA node: /sys/bus/pci/
devices/0000:65:00.0/numa_node
Your kernel may have been built without NUMA support.

...
2021-07-07 16:00:26.149385: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libcudart.so.10.1
2021-07-07 16:00:27.309024: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1096]
 Device interconnect StreamExecutor with strength 1 edge matrix:
2021-07-07 16:00:27.309079: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1102]
      0
2021-07-07 16:00:27.309101: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1115]
 0:   N
2021-07-07 16:00:27.310983: E tensorflow/stream_executor/cuda/
cuda_gpu_executor.cc:967] could not open file to read NUMA node: /sys/bus/pci/
devices/0000:65:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-07-07 16:00:27.311180: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1324]
 Could not identify NUMA node of platform GPU id 0, defaulting to 0.  Your kernel
 may not have been built with NUMA support.
2021-07-07 16:00:27.311599: E tensorflow/stream_executor/cuda/
cuda_gpu_executor.cc:967] could not open file to read NUMA node: /sys/bus/pci/
devices/0000:65:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-07-07 16:00:27.311963: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1241]
 Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 6706
 MB memory) -> physical GPU (device: 0, name: NVIDIA GeForce RTX 2080, pci bus id:
 0000:65:00.0, compute capability: 7.5)
2021-07-07 16:00:30.450162: W tensorflow/core/framework/cpu_allocator_impl.cc:81]
 Allocation of 376320000 exceeds 10% of system memory.
2021-07-07 16:00:31.962248: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libcublas.so.10
2021-07-07 16:01:15.050709: W tensorflow/core/framework/cpu_allocator_impl.cc:81]
 Allocation of 62720000 exceeds 10% of system memory.
2021-07-07 16:01:16.025014: W tensorflow/core/framework/cpu_allocator_impl.cc:81]
 Allocation of 62720000 exceeds 10% of system memory.
[I 16:02:09.048 NotebookApp] Saving file at /tensorflow-tutorials/
classification.ipynb
```

2.7.6. Deep Learning Framework Containers

Get started quickly with AI training using pre-trained models available from NVIDIA and the NGC catalog. Follow the instructions in this post for more details.

As an example, let's run a TensorFlow container to do a ResNet-50 training run using GPUs using the 20.03 container from NGC. This is done by launching the container and then running the training script from the `nvidia-examples` directory.

```
$ docker run --gpus all -it --shm-size=1g --ulimit memlock=-1 --ulimit
 stack=67108864 nvcr.io/nvidia/tensorflow:20.03-tf2-py3

================
== TensorFlow ==
================

NVIDIA Release 20.03-tf2 (build 11026100)
TensorFlow Version 2.1.0

Container image Copyright (c) 2019, NVIDIA CORPORATION.  All rights reserved.
Copyright 2017-2019 The TensorFlow Authors.  All rights reserved.

Various files include modifications (c) NVIDIA CORPORATION.  All rights reserved.
NVIDIA modifications are covered by the license terms that apply to the underlying
 project or file.

NOTE: MOFED driver for multi-node communication was not detected.
      Multi-node communication performance may be reduced.

root@c64bb1f70737:/workspace# cd nvidia-examples/
root@c64bb1f70737:/workspace/nvidia-examples# ls
big_lstm  build_imagenet_data  cnn  tensorrt
root@c64bb1f70737:/workspace/nvidia-examples# python cnn/resnet.py
...
WARNING:tensorflow:Expected a shuffled dataset but input dataset `x` is not
 shuffled. Please invoke `shuffle()` on input dataset.
2020-06-15 00:01:49.476393: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libcublas.so.10
2020-06-15 00:01:49.701149: I tensorflow/stream_executor/platform/default/
dso_loader.cc:44] Successfully opened dynamic library libcudnn.so.7
global_step: 10 images_per_sec: 93.2
global_step: 20 images_per_sec: 276.8
global_step: 30 images_per_sec: 276.4
```

Chapter 3. Troubleshooting

Here are some potential issues that you may encounter when using CUDA on WSL 2.

3.1. Container Runtime Initialization Errors

In some cases, when running a Docker container, you may encounter `nvidia-container-cli : initialization error`:

```
$ sudo docker run --gpus all nvcr.io/nvidia/k8s/cuda-sample:nbody nbody -gpu -
benchmark
docker: Error response from daemon: OCI runtime create failed:
 container_linux.go:349: starting container process caused "process_linux.go:449:
 container init caused \"process_linux.go:432: running prestart hook 0 caused
 \\\"error running hook: exit status 1, stdout: , stderr: nvidia-container-cli:
 initialization error: driver error: failed to process request\\\\n\\\"\"": unknown.
ERRO[0000] error waiting for container: context canceled
```

This usually indicates that the right Microsoft Windows Insider Preview Builds, WSL 2, NVIDIA drivers and NVIDIA Container Toolkit may not be installed correctly. Review the known issues and changelog sections to ensure the right versions of the driver, container toolkit are installed.

Ensure you have followed through the steps listed under Setup under Running CUDA containers; especially ensure that the docker daemon is still running.

```
$ sudo service docker stop
$ sudo service docker start
```

Or start the daemon directly and see if that resolves the issue:

```
$ sudo dockerd
```

If you are still running into this issue, use the dxdiag tools from the Run dialog and provide the diagnostic logs to NVIDIA by posting in the Developer Forums or by filing a report.

You can also use the CUDA on WSL 2 Developer Forums to get in touch with NVIDIA product and engineering teams for help.

3.2. Checking WSL Kernel Version

1. Ensure you have the latest kernel by running the following command in PowerShell:

```
$ wsl cat /proc/version

Linux version 5.10.16.3-microsoft-standard-WSL2
(x86_64-msft-linux-gcc (GCC) 9.3.0, GNU ld (GNU Binutils) 2.34.0.20200220) #1 SMP
 Fri Apr 2 22:23:49 UTC 2021
```

2. If you don't have the last WSL kernel updated, you will see the following blocking warning upon trying to launch a Linux distribution within the WSL 2 container.
3. If you don't have the last WSL kernel updated, you will see the following blocking warning upon trying to launch a Linux distribution within WSL 2.

3.3. Check Flighting of Preview Build Is Enabled

If your WSL kernel or the Windows preview OS build are out of date, then in the Windows Update Advanced options, make sure to enable recommended Microsoft updates. Check for windows update once again and ensure the right versions are getting updated.

Chapter 4. Release Notes

4.1. 471.21

4.1.1. Changelog

- 7/14/2021:
  - NVIDIA Driver for Windows 10 and later: 471.21
  - Windows 11 officially supported
  - WIP build: 22000, WSL Linux Kernel 5.10.43

4.1.2. New Features

The following new features are included in this release:

- None.

4.1.3. Known Limitations

The following features are not supported in this release:

1. Note that NVIDIA Container Toolkit has not yet been validated with Docker Desktop WSL 2 backend. Use Docker-CE for Linux instead inside your WSL 2 Linux distribution.
2. CUDA debugging or profiling tools are not supported in WSL 2. This capability will be added in a future release.
3. `cumemmap` IPC with fd is now supported. Other Legacy IPC APIs are not yet supported.
4. Unified Memory is limited to the same feature set as on native Windows systems.
5. With the NVIDIA Container Toolkit for Docker 19.03, only `--gpus all` is supported. This means that on multi-GPU systems it is not possible to filter for specific GPU devices by using specific index numbers to enumerate GPUs.
6. When running the NGC Deep Learning (DL) Framework GPU containers in WSL 2, you may encounter a message:

```
The NVIDIA Driver was not detected.  GPU functionality will not be available.
```

Note that this message is an incorrect warning for WSL 2 and will be fixed in future releases of the DL Framework containers to correctly detect the NVIDIA GPUs. The DL Framework containers will still continue to be accelerated using CUDA on WSL 2.

4.1.4. Known Issues

The following are known issues in this release:

- In-game Vsync fails to cap the frames to the refresh rate of the display only when Gsync is enabled. This will impact DX in-game vsync scenarios on native Windows with Gsync.

4.2. 470.76

- 6/3/2021:
  - nvidia-smi is enabled with limited feature support
  - Fixes in the NVML libraries: Symbols not exported correctly in the NVML Lib preventing the library to be loaded in some cases
  - Some performance optimization in the CUDA driver related to memory allocation
  - Bug fixes in the CUDA driver for WSL
  - NVIDIA Driver for Windows 10: 470.76
  - WIP build: 21390, WSL Linux Kernel: 5.10.16

4.3. 470.14

- 3/23/2021: Resolved issues with nvidia-smi crashing on some systems.
  - NVIDIA Driver for Windows 10: 470.14
  - WIP build: 21332, WSL Linux kernel 5.4.91
- 3/9/2021
  - WIP OS 21313+ and Linux kernel 5.4.91
  - Do not use WIP OS 21327

4.4. 465.42

- 1/28/2021: CUDA Toolkit 11.2 support, nvidia-smi, NVML support and critical performance improvements.

  The following software versions are supported with this preview release for WSL 2:

  - NVIDIA Driver for Windows 10: 465.42

- Recommended WIP build: 21292

4.5. 465.21

- 12/16/2020: Support for 3060Ti. Fix for installation problems observed in notebooks

  The following software versions are supported with this preview release for WSL 2:

  - NVIDIA Driver for Windows 10: 465.21

4.6. 465.12

- 11/16/2020: The following software versions are supported with this preview release for WSL 2:
  - NVIDIA Driver for Windows 10: 465.12

4.7. 460.20

- 9/23/2020: The following software versions are supported with this preview release for WSL 2:
  - NVIDIA Driver for Windows 10: 460.20

4.8. 460.15

- 9/2/2020:

  The following software versions are supported with this preview release for WSL 2:

  - NVIDIA Driver for Windows 10: 460.15

4.9. 455.41

- 6/19/2020: Updated driver release to address cache coherency issues on some CPU systems, including AMD Ryzen.

  The following software versions are supported with this preview release for WSL 2:

  - NVIDIA Driver for Windows 10: 455.41

4.10. 455.38

- 6/17/2020: Initial Version.

  The following software versions are supported with this preview release for WSL 2:

  - NVIDIA Driver for Windows 10: 455.38
  - NVIDIA Container Toolkit: nvidia-docker2 (2.3) and libnvidia-container (>= 1.2.0-rc.1)

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