



The science behind the report:

Lenovo ThinkBook 16p Gen 4: Spend wisely and be a pacesetter

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report [Lenovo ThinkBook 16p Gen 4: Spend wisely and be a pacesetter](#).

We concluded our hands-on testing on October 17, 2023. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on September 21, 2023 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

To learn more about how we have calculated the wins in this report, go to <http://facts.pt/calculating-and-highlighting-wins>. Unless we state otherwise, we have followed the rules and principles we outline in that document.

Performance benchmark results

Table 1: The table below represents our benchmark results in detail. Higher benchmark scores are better. We report the median score of three runs for each test.

	Lenovo ThinkBook 16p Gen 4	16-inch Apple MacBook Pro
Cinebench R23 vR23.200 (score, higher is better)		
Multi-core	19,000	14,877
Single-core	2,065	1,718
Multi-core (sustained)	17,922	14,881
Single-core (sustained)	2,065	1,642
WebXPRT 4 on Google Chrome v116.0.5845.140		
Overall score (higher is better)	336	298
Subscores (milliseconds, lower is better)		
Photo Enhancement	254	242
Organize Album Using AI	1,068	1,681
Stock Option Pricing	66	71
Encrypt Notes and OCR Scan using WASM	658	686
Sales Graphs	162	239

	Lenovo ThinkBook 16p Gen 4	16-inch Apple MacBook Pro
Online Homework	1,431	1,178
CrossMark™ v1.0.1.95 Pro (score, higher is better)		
Overall	1,898	1,818
Subscores		
Productivity	1,771	1,602
Creativity	2,199	2,274
Responsiveness	1,500	1,356
Procyon® Office Productivity Benchmark v2.6.848 using Microsoft Office v2303 Build 16227.20318		
Overall (rating, higher is better)	204,000	219,000
Subscores (higher is better)		
Word	260,000	235,000
Excel	190,000	163,000
PowerPoint	172,000	277,000
Procyon Photo Editing Benchmark v2.6.848 using Adobe Photoshop v24.7.0 & Lightroom Classic v12.5 (score, higher is better)		
Overall	7,411	7,363
Subscores		
Image retouching	8,582	6,341
Batch processing	6,400	8,550
Speedtest® by Ookla® Wireless (Mbps, higher is better)		
Download speed	784	721
Upload speed	596	446
Geekbench 6 v6.1.3 (score, higher is better)		
CPU Single-core	2,825	2,817
PugetBench Adobe Creative Cloud® (score, higher is better)		
PugetBench for Adobe Photoshop v0.93.7 using Adobe Photoshop v24.5.0	1,236	1,047
Blender Benchmark v3.5.0 (samples per minute, higher is better)		
Monster render	1662.16	951.48
Junkshop render	959.09	515.25
Classroom render	826.89	464.17
HandBrake v1.6.1		
Fast 1080p30 preset test		
Encode time (mm:ss, lower is better)	2:00	2:01
Average frames per second (higher is better)	62.59	61.23
Hardware 4K H.265 encoder test		
Encode time (mm:ss, lower is better)	0:55	1:10
Average frames per second (higher is better)	140.94	108.21
Topaz Video AI 3.3.4 FHD (frames per second, higher is better)		
FHD Chronos	6.92	3.71
FHD CHFast	11.16	6.12

	Lenovo ThinkBook 16p Gen 4	16-inch Apple MacBook Pro
Topaz Video AI 3.3.4 4K (Frames per second, higher is better)		
4K Artemis 4X	0.42	0.19
4K Proteus 4X	0.45	0.29
4K 4X Slowmow Apollo	3.02	2.53
4K APFast	11.77	10.98
4K Chronos	1.48	0.94
4K CHFast	2.82	1.40
Maxon Redshift 3D Renderer Benchmark v3.5.03		
Render time (seconds, lower is better)	235	422
MLPerf v3.1 - ResNet50 v1.5 (Offline)		
Samples per second (higher is better)	8,132.24	756.45

System and application responsiveness results

Table 2: The table below represents our hand-timed test findings in detail. Lower times are better. We report the median time of three runs for each test.

	Lenovo ThinkBook 16p Gen 4	16-inch Apple MacBook Pro
System boot and shutdown (seconds, lower is better)		
Time to resume from sleep	15.56	19.38
Microsoft Office Word (seconds, lower is better)		
Time to open 90MB Word document	0.8	0.9
Time to perform word Find/Replace	0.9	1.1
Microsoft Office Excel (seconds, lower is better)		
Time to launch	0.7	0.8
Time to open 92MB Excel spreadsheet containing macro	10.7	12.7
Time to open 650KB 10K row Excel spreadsheet	0.6	0.8
Time to insert 3-D 100% Stacked Column Chart	16.5	21.4
Microsoft Office PowerPoint (seconds, lower is better)		
Time to export 180MB PPTX to PDF	6.5	8.3
Adobe Photoshop performance (seconds, lower is better)		
Time to process and convert 50 RAW NEF images to JPEG format	70.6	79.0

Zoom video conferencing

Table 3: The table below represents our CPU findings in detail. Lower percentages are better. We report the median percentage of three runs.

	Lenovo ThinkBook 16p Gen 4	16-inch Apple MacBook Pro
System maximum CPU utilization while using Zoom (percent utilization, lower is better)		
Host, 1:1 meeting	5	18
Guest, 1:1 meeting	2	12
Host, 1:3 meeting	4	22

Audio testing

Table 4: The table below represents our audio findings in detail. Lower LUFS are better and lower percentage of maximum volume output to reach target dB is better. We report the median score of three runs for each test.

	Lenovo ThinkBook 16p Gen 4	16-inch Apple MacBook Pro
Microphone noise reduction		
Background fan volume (LUFS)	NA (did not register the fan noise)	Registered audible noise at -41.6 LUFS
Speaker volume output required to reach 64 dB		
Volume (percent, lower is better)	64	75

System configuration information

Table 5: Detailed information on the systems we tested.

System configuration information	Lenovo ThinkPad 16p	Apple MacBook Pro 16
Processor		
Vendor	Intel®	Apple
Model number	Core™ i9-13900H	M2
Core frequency (GHz)	4.1-5.40	3.68
Number of cores	14	12
Logical processors	20	
Memory		
Amount (GB)	32	32
Type	DDR5	Unified
Graphics #1		
Vendor	Intel	Apple
Model number	Intel Iris® X ^e Graphics	M2 38-core GPU
Graphics #2		
Vendor	NVIDIA®	N/A
Model number	GeForce RTX™ 4060	N/A
Driver	31.0.15.3734	N/A
Storage		
Amount (TB)	1	1
Type	SSD	SSD
Connectivity/expansion		
Wireless internet	Intel Wi-Fi 6E AX211	Wi-Fi 6E (802.11ax)
Bluetooth	5.2	5.3
USB	1 x SD card reader 1 x USB-C 3.2 1 x Thunderbolt® 4 ports 2 x USB-A 3.2 1 x HDMI® port 1 x pogo-pin connector (for Magic Bay accessories) 1 x Kensington Nano Security Slot	1 x SDXC card slot 1 x HDMI port 3 x Thunderbolt 4 ports
Battery		
Type	Integrated Lithium-polymer	Integrated Lithium-polymer
Rated capacity (Whr)	84	100
Display		
Size (in.)	16.3	16.2
Resolution	3,200 x 2,000	3,456 x 2,234

System configuration information	Lenovo ThinkPad 16p	Apple MacBook Pro 16
Operating system		
Vendor	Microsoft	Apple
Name	Windows 11 Pro	macOS Ventura
Version	22H2 Build 22621.2134	13.5.1
BIOS		
BIOS name and version	Lenovo LRCN34WW	8422.141.2
Dimensions		
Height (in.)	0.78	0.44
Width (in.)	13.96	11.97
Depth (in.)	10.03	8.46
Weight (system) lbs.	4.85	2.70

How we tested

Setting up the system (Windows)

Setting up and updating the OEM image

1. Boot the system under test (SUT).
2. Follow the on-screen instructions to complete installation, using the default selections when appropriate.
3. Set the Windows (plugged in) Power Mode to Best Performance.
4. Set Screen and Sleep options to Never:
 - a. Right-click the desktop, and select Display settings.
 - b. From the left column, select System.
 - c. Click Power & Battery.
 - d. For all power options listed under Screen and Sleep, select Never.
5. Disable User Account Control notifications:
 - a. Select Windows Start, type UAC, and press Enter.
 - b. Move the slider control to Never notify, and click OK.
6. Run Windows Update, and install all updates available.
7. Verify the date and time are correct, and synchronize the system clock with the time server.
8. Pause Automatic Windows Updates:
 - a. Click the Windows Start button.
9. Type `Windows Update settings` and press Enter.
 - a. From the Pause updates drop-down menu, select Pause for 5 weeks.

Setting up the system (macOS)

Setting up and updating the OEM image

1. Boot the SUT.
2. Follow the on-screen instructions to complete installation, using the default selections when appropriate.
3. Set Screen and Sleep options to Never:
 - a. Select System Settings.
 - b. Select Screensaver.
 - c. Set Lock Screen Settings to Never.
 - d. Return to System Settings, and select Battery.
 - e. Set On power adapter setting to High Power.
4. Disable Automatically adjust brightness:
 - a. Select System Settings.
 - b. Select Display.
 - c. Disable Automatically adjust brightness.
5. Run Software Update, and install all updates available.
6. Verify the date and time are correct.
7. Enable Automatic log in:
 - a. Select System Settings.
 - b. Click Users & Groups.
 - c. Select the drop-down menu next to the Automatically log in as setting, and select the User account.
8. Disable Automatic Mac Updates:
 - a. Select System Settings.
 - b. Click General.
 - c. Click Software Update.
 - d. Click the information icon next to Automatic updates.
 - e. Disable Check for updates.

Performance benchmark testing

Cinebench R23 benchmark testing

Setting up the Cinebench R23 test (Windows & macOS)

1. Download and install Cinebench from <https://www.maxon.net/en/downloads/cinebench-r23-downloads>.

Running the Cinebench R23 benchmark (Windows & macOS)

1. Launch Cinebench.
2. Select File→Advanced benchmark.
3. Set the Minimum Test Duration to Off.
4. Select either CPU (Multi Core) or CPU (Single Core), and click Start.
5. Record the result.
6. Wait 15 minutes before re-running.
7. Repeat steps 1 through 6 two more times.

BAPCo CrossMark benchmark testing

Setting up the test (Windows & macOS)

1. Download and install CrossMark from the Microsoft Store or Apple App Store.

Running the test (Windows & macOS)

1. Launch CrossMark.
2. Click Settings.
3. For Number of Iterations, choose 1.
4. Enter a valid email address, and click Back.
5. Click Run Benchmark.
6. Record the result.
7. Repeat steps 1 through 6 two more times.

WebXPRT 4 benchmark testing (Google Chrome)

Running the test (Windows & macOS)

1. Open the Web browser under test, and go to <https://www.principledtechnologies.com/benchmarkxpert/webxpert/>.
2. Click Run WebXPRT 4.
3. At the Ready to test your browser screen, click Continue.
4. Click Start.
5. When the test completes, record the results.
6. Click Run Again, and click Start to rerun WebXPRT. Record the results.
7. Repeat step 6 two more times.

Speedtest by Ookla testing

Setting up the test (Windows & macOS)

1. Download and install the Chrome web browser from <https://www.google.com/chrome/downloads/>.

Running the test (Windows & macOS)

1. Open the Chrome web browser, and go to <https://www.speedtest.net/>.
2. Verify that the systems under test are using the same server.
3. To start the benchmark, click Go.
4. Record the result.
5. Repeat steps 1 through 4 twice more.

Maxon Redshift 3D Renderer benchmark testing

Setting up the test (Windows & macOS)

1. Download and install the Maxon App from <https://www.maxon.net/en/try>.
2. Click the Maxon One 14-day trial, download it, and install the RedShift application.

Running the test (Windows)

1. Open a command prompt by clicking the Windows icon on the bottom left of your desktop, typing `cmd` and then pressing enter.
2. Inside the command prompt, type `cd C:\ProgramData\Redshift\bin` and press Enter.
3. To start the benchmark, type `RunBenchmark.bat` and press Enter.
4. Record the results.
5. Wait 5 minutes before performing the next run.
6. Repeat steps 1 through 5 twice more.

Running the test (macOS)

1. Open a terminal window by opening the Launchpad, typing `Terminal` and pressing enter.
2. Inside the terminal, type `cd /Applications/redshift/bin` and press Enter.
3. To start the benchmark, type `sh runBenchmark.sh` and press Enter.
4. Record the results.
5. Wait 5 minutes before performing the next run.
6. Repeat steps 1 through 5 twice more.

PugetBench Adobe Creative Cloud benchmark testing

Puget Systems Adobe CC benchmarks are designed to thoroughly test many of Adobe's most popular software packages using real world projects and workflows.

PugetBench for Photoshop testing

We used the following application:

- Adobe Photoshop

Setting up the test (Windows & macOS)

1. Launch Adobe Photoshop.
2. Click through the Tutorial pop-up tips.
3. Close Adobe Photoshop.
4. Purchase and download the PugetBench for Photoshop license from <https://www.pugetsystems.com/labs/articles/PugetBench-for-Adobe-Creative-Cloud-1642/>.
5. Click Get on Adobe Marketplace, and log into your Adobe account.
6. Click the PugetBench Photoshop Plug-in to install it.
7. Open Adobe Photoshop.
8. Click `Window` → `Extensions` → `PugetBench for Photoshop`.
9. Next to License Key, click `Change`, and enter your license key. Click `Save`.

Running the test (Windows & macOS)

1. Boot the system.
2. Open Adobe Photoshop.
3. Click `Window` → `Extensions` → `PugetBench for Photoshop`.
4. Click `Run Benchmark`.
5. Record the overall score when the benchmark finishes.
6. Close Adobe Photoshop, and restart the SUT.
7. Wait 15 minutes before performing the next run.
8. Repeat steps 1 through 7 twice more, and record the median result.

Blender benchmark testing

Setting up the test (Windows & macOS)

1. Download the Blender Benchmark from <https://opendata.blender.org/>.

Running the test (Windows & macOS)

1. Launch the Blender Benchmark.
2. At the Welcome screen, click Next.
3. Select Blender version 3.5.0, and click Next.
4. At the Benchmark Scenes screen, click Next.
5. At the Benchmark Device screen, select the GPU option, and click Start Benchmark.
6. Record the results.
7. Wait 15 minutes before performing the next run.
8. Repeat steps 1 through 7 two more times.

HandBrake video encoding testing

Setting up the Fast 1080p30 preset and Hardware 4K H.265 encoder tests

1. Download HandBrake from <https://handbrake.fr/downloads.php>
2. Install HandBrake with default options.
3. Copy the 4K file to be transcoded to the test system.
4. Launch HandBrake.
5. Browse to the 4K source file, click Open.

Running the Fast 1080p30 preset test (Windows & macOS)

1. Click the Chapters tab, and uncheck the Create chapter markers box.
2. Click Start Encode.
3. When complete, click the Show Queue menu item to view the encoding statistics.
4. Repeat steps 1 through 3 two more times.

Hardware 4K H.265 encoder test

The Lenovo tested with NVENC due to the NVIDIA graphics chip. The Mac tested with QSV encoder because NVENC is an NVIDIA-only encoder.

Running the Hardware4K H.265 encoder test (Windows)

1. Click the Preset drop-down menu, and select H.265 NVENC 2160p 4K.
2. On the Video tab, change the Framerate (FPS) to 60.
3. Set the preset to Fast.
4. On the Chapters tab, uncheck the Create chapter markers box.
5. Click Start.
6. When complete, click the Show Queue menu item to view the encoding statistics.
7. Repeat steps 1 through 6 two more times.

Running the Hardware4K H.265 encoder test (macOS)

1. Click the Preset drop-down menu, and select H.265 MKV 2160p 60.
2. Change the Format to MP4.
3. On the Filters tab, set all to Off.
4. On the Video tab, change the Video Encoder to H.265 (VideoToolbox).
5. Set the preset to Speed.
6. On the Chapters tab, uncheck the Create chapter markers box.
7. Click Start.
8. When complete, click the Show Queue menu item to view the encoding statistics.
9. Repeat steps 1 through 8 two more times

Topaz Video AI testing

Setting up the test (Windows & macOS)

1. Purchase a Pro license, and download and install Topaz Video AI 3.3.4 from <https://www.topazlabs.com/downloads>.

Running the test in 3,480x2,160 (4K) (Windows & macOS)

1. Launch Topaz AI.
2. Close the activation window.
3. Select Process→ Benchmark.
4. from the Input Resolution drop-down menu, select 3840x2160 (4K).
5. Click Benchmark.
6. When the test completes, record the results.
7. Wait 15 minutes before retesting.
8. Repeat steps 1 through 7 two more times.

Hand-timed custom Microsoft 365 workflow scenarios

Time to complete the hand-timed Microsoft PowerPoint scenario

We recorded how long it took to launch PowerPoint, open a 180MB PowerPoint PPTX file, start a slideshow task, and export a PPTX to PDF. A stopwatch is required for this test.

We used the following application:

- Microsoft PowerPoint (Windows v16.0.16731.20194 & macOS v16.76.1.23082301)

Running the test (Windows & macOS)

1. Simultaneously start the timer and launch PowerPoint.
2. Stop the timer when PowerPoint has loaded.
3. Browse to where the test PowerPoint file is located.
4. Simultaneously start the timer and open the PowerPoint file.
5. Stop the timer when the PowerPoint file has loaded, as indicated by all 33 slides appearing in the side bar, and record the results.
6. Simultaneously start the timer and press F5 to start the slide show.
7. Stop the timer when the slide show starts to play.
8. Exit the slide show.
9. Click File→Export→Create PDF/XPS.
10. Simultaneously start the timer and click Publish.
11. Stop the timer when the PDF has been created, and record the results.
12. Repeat steps 1 through 11 two more times.

Time to complete the hand-timed Microsoft Excel scenario

We recorded how long it took to launch Excel, open a 92MB macro Excel XLSX file, open a 650KB 10K row Excel XLSX and insert a 3D 100% stacked column chart into the 10K row spreadsheet. A stopwatch is required for this test.

We used the following application:

- Microsoft Excel (Windows v16.0.16731.20194 & macOS v16.76.23081101)

Running the test (Windows & macOS)

1. Simultaneously start the timer and launch Excel.
2. Stop the timer when Excel has loaded.
3. Browse to where the test Excel macro file is located.
4. Simultaneously start the timer and open the Excel macro file.
5. Stop the timer when the Excel file has loaded.
6. Close the macro test file.
7. Browse to where the test Excel 10K row file is located.
8. Simultaneously start the timer and open the 10K row file.

9. Stop the timer when the Excel file has loaded.
10. Click Insert, and select the drop-down menu next to the Insert Column or Bar Chart icon.
11. At the bottom of the drop-down menu, select More Column Charts.
12. Under the Column section, choose 3-D 100% Stacked Column.
13. Simultaneously start the timer and click Ok.
14. Stop the timer when the 3-D 100% Stacked Column Chart appears.
15. Repeat steps 1 through 14 two more times.

Time to complete the hand-timed Microsoft Word scenario

We recorded how long it took to launch Word, open a 90MB Word DOCX file, perform a find/replace task, and export a DOCX file to PDF. A stopwatch is required for this test.

We used the following application:

- Microsoft Word (Windows v16.0.16731.20194 & macOS v16.49.23082301)

Running the test (Windows & macOS)

1. Simultaneously start the timer and launch Word.
2. Stop the timer when Word has loaded.
3. Locate the test Word file.
4. Simultaneously start the timer and open the Word file.
5. Stop the timer when the Word document has fully loaded.
6. Press CTRL + H/Control + H to bring up the Find/Replace dialog box.
7. In the Find What field, type I
8. In the Replace With field, type TEST
9. Simultaneously start the timer and select Replace All.
10. Stop the timer when Word has replaced every I.
11. Click File→Export→Create PDF/XPS.
12. Simultaneously start the timer and click Publish.
13. Stop the timer when the Word has exported the document to PDF.
14. Close the Word document. Do not save changes.
15. Repeat steps 1 through 14 two more times.

Machine learning testing

Configuring Ubuntu 20.04 on Windows 11 WSL2 using NVIDIA CUDA

1. Confirm that hardware virtualization is enabled in the system BIOS.
2. Enable Hyper-V and Virtual Machine Platform in Windows:
 - a. Open an elevated PowerShell terminal.
 - b. Run the following commands, but decline the reboot until the final step.

```
Enable-WindowsOptionalFeature -Online -FeatureName Microsoft-Hyper-V-All
Enable-WindowsOptionalFeature -Online -FeatureName VirtualMachinePlatform
shutdown /r /t 0
```

3. Download and install drivers from NVIDIA.com: <https://www.nvidia.com/download/index.aspx>.
4. If a professional GPU is installed, enable Error Correction Code in the NVIDIA Control Panel.
5. Confirm GPU configuration. From an elevated terminal session, run `nvidia-smi` to validate GPUs and drivers are recognized.
6. Verify ECC is enabled:

```
nvidia-smi -q -d ECC
```

7. Install Ubuntu 20.04:

```
wsl.exe --install Ubuntu-20.04
```

8. Follow the prompts to create an Ubuntu user name and password.
9. Exit the Ubuntu session.
10. Set default WSL instance to the new installation:

```
wsl --set-default Ubuntu-20.04
```

11. Update WSL2 to latest release:

```
wsl --update --pre-release
```

12. Reboot the system:

```
shutdown /r /t 0
```

13. Open a new Terminal session to Ubuntu 20.04.

14. Update Ubuntu:

```
sudo apt update && sudo apt upgrade
```

Configuring the CM machine learning environment

1. Install prerequisites:

```
sudo apt install python3 python3-pip python3-venv git wget curl zlib1g unzip
```

2. Modify the `/etc/profile` file by adding the following lines:

```
export PATH="/home/ptuser/.local/bin:$PATH"
export PATH="/usr/local/cuda-11.8/bin:$PATH"
export LD_LIBRARY_PATH="/usr/local/cuda-11.8/lib64"
export CUDA_MODULE_LOADING=LAZY
```

3. Install CM:

```
python3 -m pip install cmind
```

4. Exit, and restart terminal to add paths to environment.
5. Test CM:

```
cm test core
```

6. Use CM to pull the MLCommons GitHub repository:

```
cm pull repo mlcommons@ck
```

Configuring WSL NVIDIA support

1. Install CUDA for Linux:

```
mkdir nvidia-prereq
cd nvidia-prereq
wget https://developer.download.nvidia.com/compute/cuda/11.8.0/local_installers/
cuda_11.8.0_520.61.05_linux.run
sudo sh cuda_11.8.0_520.61.05_linux.run
```

2. Test CUDA support:

```
cmr "get cuda-devices"
```

3. Install CUDA into CM:

```
cmr "get cuda"
```

4. Install cuDNN & TensorRT:

```
cmr "get cudnn" --tar_file=~/.nvidia-prereq/cudnn-linux-x86_64-8.9.5.29_cuda11-archive.tar.xz
cmr "get tensorrt_dev" --tar_file=~/.nvidia-prereq/TensorRT-8.6.1.6.Linux.x86_64-gnu.cuda-11.8.tar.gz
```

5. Install system dependencies:

```
cm run script "get sys-utils-cm" --quiet
cm run script "get python" --version_min=3.8
pip install packaging tqdm
```

Confirming GPUs are recognized by the CM environment

1. Run `cmr get-cuda-devices`
2. Confirm the devices listed match the system configuration.

Configuring macOS

Installing Brew

1. Open a Terminal window.
2. Run `/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"`
3. Run these two commands in your terminal to add Homebrew to your PATH:

```
(echo; echo 'eval "$(/opt/homebrew/bin/brew shellenv)'"') >> /Users/ptuser/.zprofile  
eval "$(/opt/homebrew/bin/brew shellenv)"
```

Configuring the CM machine learning environment

1. Install Python prerequisites:

```
brew install python3 git wget curl
```

2. Install GCC:

```
brew install gcc
```

3. Install CM:

```
python3 -m pip install cmind
```

4. Add CM to path:

- a. Run `nano ~/.zprofile`
- b. Add the following line:

```
export PATH="$PATH:./Library/Python/3.9/bin"
```

- c. Activate the new path: `source ~/.zprofile`
- d. Close and reopen Terminal to ensure paths take effect.

5. Update pip:

```
/Library/Developer/CommandLineTools/usr/bin/python3 -m pip install --upgrade pip
```

6. Create the Python virtual environment:

```
python3 -m venv ~/venv-metal  
source ~/venv-metal/bin/activate  
python -m pip install -U pip
```

7. Install tensorflow and tensorflow-metal into the Python virtual environment:

```
python -m pip install tensorflow  
python -m pip install tensorflow-metal
```

8. Pull mlcommons CM repo:

```
cm pull repo mlcommons@ck
```

Verifying installation

1. Run Python:

```
python
```

2. Input and execute the following code block. If results return, the test was successful.

```
import tensorflow as tf
cifar = tf.keras.datasets.cifar100
(x_train, y_train), (x_test, y_test) = cifar.load_data()
model = tf.keras.applications.ResNet50(
    include_top=True,
    weights=None,
    input_shape=(32, 32, 3),
    classes=100,)
loss_fn = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=False)
model.compile(optimizer="adam", loss=loss_fn, metrics=["accuracy"])
model.fit(x_train, y_train, epochs=5, batch_size=64)
```

The ML testing scripts

ResNet-50 - CUDA

```
cmr "generate-run-cmds inference _find-performance" \
--model=resnet50 \
--implementation=nvidia-original \
--device=cuda \
--backend=tensorrt \
--category=edge \
--division=open \
--execution-mode=valid \
--results_dir=$HOME/MLPerf_OOB \
--quiet \
--clean
```

ResNet-50 - Metal

```
cmr "generate-run-cmds inference _find-performance" \
--model=resnet50 \
--backend=tf \
--category=edge \
--division=open \
--execution-mode=valid \
--results_dir=$HOME/MLPerf_OOB \
--quiet \
--clean
```


Video-conferencing testing

Preparing to install Zoom (Windows)

1. Open Edge.
2. Navigate to <https://zoom.us/downloads>.
3. Under Zoom Desktop Client, click Download.
4. When the file is done downloading, click Open File to begin the installation.

Installing Zoom (Windows)

1. In the Installer, click Continue.
2. Click Yes to allow Zoom to install on Allow this program to make changes to your device.
3. When the installation finishes, click Done.

Configuring Zoom (Windows)

1. Right-click the Zoom icon in the tray, and click Check for Updates.
2. Click Ok to download updates.
3. Click Install to install updates.
4. If there are no updates, click Close.
5. Right-click the Zoom icon in the tray, and click Settings.
6. Under General, enable Enter full screen when starting or joining a meeting.
7. Under Preferences, click Video.
8. Click OK to allow Zoom access to the Camera.
9. Click Audio.
10. Click OK to allow Zoom access to the microphone.
11. Enable Automatically join computer audio when joining.
12. Click Share Screen.

Preparing to install Zoom (macOS)

1. Open Safari.
2. Navigate to <https://zoom.us/downloads>.
3. Under Zoom Desktop Client, click Download.
4. When prompted to allow downloads from zoom.us, click Allow.
5. When the download is complete, click the download icon on the Mac taskbar, and select zoomusInstallerFull.pkg.

Installing Zoom (macOS)

1. In the Installer, click Continue.
2. Click Install.
3. If prompted to enter user password, do so, and press enter. Otherwise, click Install.
4. Click OK to allow Installer to access files.
5. When the installation completes, click Done.

Configuring Zoom (macOS)

1. Navigate to the menu at the top of the screen, and click Check for Updates.
2. Click Ok to download updates.
3. Click Install to install updates.
4. Under General, enable Enter full screen when starting or joining a meeting.
5. Under Preferences, click Video.
6. Click OK to allow Zoom access to the Camera.
7. Click Audio.
8. Click OK to allow Zoom access to the microphone.
9. Enable Automatically join computer audio when joining.
10. Click Share Screen.
11. Enable Side-by-Side Mode.

Configuring the Zoom account on the Zoom.com portal

1. Navigate to Zoom.us, and sign into the admin account you will use to host the Zoom calls.
2. Navigate to Settings, under Personal.
3. Click Meeting.
4. Scroll down and enable the following:
 - Start meetings with host video on.
 - Start meetings with participant video on. Participants can change this during the meeting.

Configuring the host for a Zoom call

1. Click Sign in to log into Zoom.
2. Enter Username.
3. Enter Password.
4. Check Keep me signed in.
5. Click Sign in.
6. Close out of the Zoom experience by pressing the X in the top right of the pop-up window.
7. On the Zoom landing page, click the down arrow under New Meeting, and check to enable Use my Personal Meeting ID (PMI).

Notes on testing

- Once in the call, we used screen share to display a PowerPoint.
- To simulate talking that all devices could hear, we played audio from a YouTube video in the background.
- We pointed all devices at an oscillating fan to simulate movement for the duration of the test.
- The call lasted 10 minutes, starting from the time all devices were in the call, all cameras were on, a user had turned on screenshare, and audio was playing .

Joining a Zoom call as a guest

1. Click Join a Meeting.
2. Enter the Personal Meeting ID of the host meeting.
3. Click Join.

Audio quality testing

Note: We conducted testing in an audio room with an enclosed sound booth. In addition to the SUTs, we used one additional system, located in the audio room. We connected this system to the speaker in the sound booth.

Pre-test setup

1. Install Audacity on each SUT, and confirm that there are no issues with on-board mic recording.
2. Install VLC media player as a consistent media player on all SUTs.
3. Trim the sample song so that a roughly 20-second sample of the loudest part of the song remains.
4. Load the sample song file onto each SUT using a USB drive.

Microphone noise reduction

Setup

1. Place the Yamaha speaker in the sound booth, near the position where a laptop user would be speaking. Connect the speaker to the audio room computer, on which you have loaded a speaking sample representative of normal conversation. Use this same sample for each test for consistency.
2. Set the input volume of the onboard microphone to approximately 98%.
3. Place the SUT on the desk in the sound booth, and open Audacity. Measure the angle of screen tilt to maintain consistency across all SUTs. Press Record, and exit the sound booth.
4. On the audio room computer, press Play to play the speaking sample (roughly 20 seconds long).
5. Enter the sound booth, and stop recording in Audacity.
6. Transfer the recorded file to the audio room computer to analyze in Pro tools.
7. To match the stereo format of the Lenovo device recording, duplicate the Mac's mono audio file and combine the two mono duplicates into a single stereo track.
8. Use FabFilter Pro L2 in the Integrated setting in Loudness mode to measure the average loudness of both clips. Using clip gain as needed, level match clips to -21.1 LUFS. Note the volume difference of each system.
9. Add a fan in back corner of the sound booth, roughly 5 feet from the speaker. Keep the fan on and running at consistent speed during tests.

Testing

1. Place the SUT on the desk in the sound booth, and open Audacity. Measure the angle of screen tilt to maintain consistency across all SUTs. Press Record, and exit the sound booth.
2. Record at least 20 seconds of only fan noise.
3. Enter the sound booth, and stop recording in Audacity.
4. Transfer the recorded file to the audio room computer to analyze in Pro tools.
5. Level match recordings from both SUTs using the adjustment parameter from the "Setup" section.
6. Measure the volume level of fan noise using FabFilter Pro L2 using the Integrated setting in Loudness mode.

Maximum speaker volume output

Setup

1. Load VLC on each of the 12 SUTs with the file comprising the sample song clip.
2. Place Cirrus SPL meter in the audio booth in the same location as the speaker from Test 1.

Testing

1. Place the SUT on the desk in the sound booth. Measure the angle of screen tilt to maintain consistency across all SUTs.
2. Using the sample song clip and Cirrus SPL meter, adjust the output volume of each SUT to 64 dB. Measure SPL of all SUTs from the same distance and position. Document volume output level of SUT (0 percent to 100 percent).

Read the report at <https://facts.pt/8gAjkYB>



This project was commissioned by Lenovo.



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