Lenovo

Implementing Intel Optane DC Persistent Memory on Windows Server 2019

Describes how to configure DCPMM on Windows Server 2019

Includes the PowerShell commands used to configure DCPMM

Explains how to use the Lenovo PmemTool to work with DCPMMs

Shows how to check DCPMM status in Device Manager and Task Manager

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Abstract

Intel Optane DC Persistent Memory is based on Intel 3D XPoint non-volatile memory technology and is implemented in Lenovo® ThinkSystem™ servers. The use of DC Persistent Memory Modules (DCPMMs) enables software applications to take advantage of the larger memory capacities, data persistence and the resulting improved performance of the server.

This document shows how Microsoft Windows implements persistent memory, how to configure and manage DCPMM on Windows Server 2019, and how to utilize it in Hyper-V.

The intended audience of this document is IT professionals, technical architects and software engineers. It is expected that readers have some knowledge of persistent memory and the using Windows Server tools such as PowerShell and Task Manager.

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Overview

Intel Optane DC Persistent Memory represents a new class of memory and storage technology explicitly architected for data center usage. DC Persistent Memory Module (DCPMM) capacity can be configured as Memory Mode, App Direct Mode, or a combination of both.

- In Memory Mode, DCPMMs act as volatile system memory under the control of the operating system. Any DRAM in the platform will act as a cache working in conjunction with the DCPMMs.
- In App Direct Mode, DCPMMs and standard DDR4 memory DIMMs act as independent memory resources under direct load/store control of one or more applications. DCPMM capacity is directly accessible by applications and the memory can be byte-addressable.
- In Mixed Mode, a percentage of DCPMM capacity is used in Memory Mode and the remaining in App Direct Mode.

In App Direct mode (and the persistent portion of Mixed mode), the persistent memory can be configured in one of the following two ways:

- Interleaved, where all DCPMMs per socket act as one single logic disk.
- Non-interleaved, where each DCPMM acts as a separate one.

Implementation requirements

The following are some general instructions you need to follow before installing DCPMMs in your server(s):

- Update the system firmware.

  It is recommended to update the system firmware before implementing DCPMMs. For details about firmware updating options, see this InfoCenter topic:

  https://thinksystem.lenovofiles.com/help/index.jsp?topic=%2F7X21%2Fupdate_the_firmware.html

- Select matched processors.

  DCPMMs require second generation Intel Xeon Scalable Family processors. You can find the matched processors from the DCPMM Product Guide:

  https://lenovopress.com/lp1066-intel-optane-dc-persistent-memory#processor-support

- Choose correct DCPMMs and DIMMs by following requirements below:
  - Sizes of all installed DCPMMs must be the same.
  - Sizes and part numbers of all installed DIMMs must be the same.
  - Selection of DCPMMs and DIMMs varies in different configuration scenarios:
    - For Memory Mode, minimum 2 DCPMMs per processor (install 1 per memory controller)
    - For App Direct Mode, a maximum of 1x DCPMM device is allowed per memory channel. For each memory channel, DCPMM devices should be installed in the memory slot physically closest to the CPU unless it is the only DIMM in the memory channel.
    - When DCPMM is configured in memory mode or mixed mode, DIMM/DCPMM ratio is suggested to be between 1:4 and 1:16.

Note: For more requirements about processors, servers, DIMMs and implementation, see Intel Optane DC Persistent Memory Production Guide.

https://lenovopress.com/lp1066-intel-optane-dc-persistent-memory

- Install DCPMMs and DIMMs in the correct order by referring to:

  https://thinksystem.lenovofiles.com/help/index.jsp?topic=%2F7X21%2Fmemory_module_installation_order_aep.html

- Update the DCPMM firmware to the latest version. Please refer to

  https://sysmgt.lenovofiles.com/help/index.jsp?topic=%2Fcom.lenovo.lxca.doc%2Fupdate_fw.html

Persistent Memory

Implementing persistent memory (PMEM) brings architectural changes to a server. In the new architecture, to store or retrieve data, processors can have byte-level access to non-volatile memory via memory bus. As the name suggests, even after a power cycle, the data accessed by processors is still available. There are fewer I/O trips and the latency is significantly reduced. PMEM is provided through Microsoft's Storage Class Memory (SCM) driver.

Architecture

There are two types of device objects related to persistent memory on Windows

- Physical NVDIMMs
- Logical persistent memory disks

In Device Manager, physical NVDIMMs appear under "Memory devices", while logical disks are under "Persistent memory disks".

All DCPMMs are managed by the nvdimm.sys driver, while the logical disks are controlled by pmem.sys. Both types of device objects are created by scmbus.sys, the bus driver for persistent memory. You can find the bus driver object in Device Manager under "System Devices".

DAX (direct access)

There are two ways to access persistent memory, DAX and block mode. DAX is the mechanism that enables direct access to files stored in persistent memory arrays without the need to copy the data through the page cache. Block mode is the storage over AD mode that Intel names for DCPMM.

Using storage class memory in block mode means a legacy application doesn't need to be changed. DAX can only be used with the NTFS file system while block mode can be used with NTFS and ReFS file systems.

DAX supports two types of applications. Legacy applications use standard file API, such as open, close operation to access PM-aware file system. For PMDK (Persistent Memory Development Kit) applications, memory mapped files will provide them with direct access to PMEM. If you want to use DAX, you need to choose it at volume format time.

vPMEM (virtual persistent memory) support

Virtual persistent memory is newly supported on Windows Server 2019. Storage-class memory support for VMs enables NTFS-formatted direct access volumes to be created on non-volatile DIMMs and exposed to Hyper-V VMs. This enables Hyper-V VMs to leverage the low-latency performance benefits of storage-class memory devices.

The following are steps for configuring Windows vPMEM:

1. Configure DCPMM to be App Direct mode
2. Format this PM device and suppose the drive letter is D.
3. Create a persistent memory device for a VM

   ```
   PS> New-VHD d:\VPMEMDevice1.vhdpmem -Fixed -SizeBytes 128GB
   ```

4. Create a Generation 2 VM with specified memory size and path to a VHDX image

   ```
   PS> New-VM -Name ProductionVM1 -MemoryStartupBytes 32GB -Generation 2
   -NewVHDPath c:\testHyperV\BaseImage.vhdx -NewVHDSizeBytes 200GB
   ```

5. Add persistent memory controller to the VM

   ```
   PS> Add-VMPmemController ProductionVM1
   ```

6. Attach persistent memory device to the VM's controller.

   ```
   PS> Add-VMHardDiskDrive ProductionVM1 PMEM -ControllerLocation 1 -Path
   D:\VPMEMDevice1.vhdpmem
   ```

7. Start this virtual machine and install Windows Server 2019
8. After the installation is finished, open disk manager, it will show 128 GB PM disk waiting to be initialized.

After finishing these steps and start the Hyper-V, you will find the attached PMEM device in VM's disk manager. You should use PowerShell commands for the creation and management of virtual persistent memory.

Pay attention that a VHDPMEM should always be on a DAX volume. That's because a VHDPMEM is exposed to the guest OS as an NVDIMM, and the guest OS needs direct access to the physical memory that corresponds to that VHDPMEM. That is only possible through DAX.

DCPMM configurations

In this paper, all the examples are from a ThinkSystem SR650 server with "2-2-1" memory population. We configure it with 8x 128 GB DCPMMs, 12x 32 GB DDR4, and two Intel Xeon Gold 6252 processors.

Topics in this section:

Create a goal

A goal refers to platform configuration data stored in the DCPMM metadata region describing a configuration request. After you have configured the goal, you specify which mode the DCPMMs works in.

Creating a goal is required in all modes or scenarios. It is recommended you create a goal via UEFI settings.

Go to **UEFI Setup** → **System Settings** → **Intel Optane DCPMMs** → **Goals**. For details, refer to the following InfoCenter page:

https://thinksystem.lenovofiles.com/help/index.jsp?topic=%2F7X21%2Fmemory_configuration_dcpmm.html&cp=2_0_7_4_0

Note: A reboot is required after the provisioning.

Create namespaces

A namespace defines a contiguous address range of non-volatile memory conceptually similar to a hard disk partition, SCSI Logical Unit (LUN), or an NVMe namespace. It is the unit of persistent memory storage that can be used for input/output (I/O).

Creating namespaces is only needed in App Direct mode and mixed mode. Before creating a namespace, make sure that the DCPMMs are unlocked and the Health Status of the region is Healthy.

The following are rules you need to follow for creating namespaces on Windows Server 2019:

- Windows only supports one namespace per interleave set.
- Windows doesn't support partial namespaces, multiple namespaces in one interleave set.
- Recommendation from Microsoft is to always create a namespace that covers the entire interleave set.

It is recommended to create namespaces using PowerShell commands. For detailed steps, see step 3 on page 7.

You can also create namespaces in UEFI settings as follows:

1. Go to UEFI Setup > System Settings > Intel Optane DCPMMs > Namespaces > Create Namespace to create namespace for DCPMMs.
2. The allocated capacity needs to be set as zero to cover the whole region, see Figure 1.

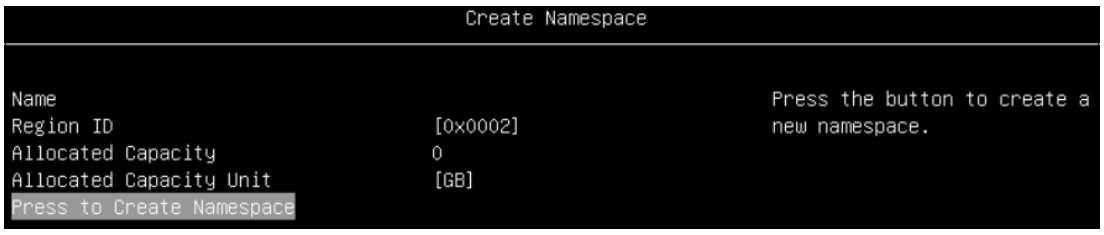

Figure 1 Create namespace for DCPMM in UEFI settings

3. Remember to create a namespace for every region ID respectively.

Configure DCPMMs using PowerShell commands

It is recommended to create a goal first in UEFI settings before further configurations using PowerShell commands. The following are example steps for the configurations:

1. Return the information of one or more physical persistent memory devices, including device type, healthy status and physical location, etc.

   ```
   PS> Get-PmemPhysicalDevice
   ```

   The output of the command is shown in Figure 2 on page 7.

```
PS C:\Users\Administrator> Get-PmemPhysicalDevice

DeviceId DeviceType           HealthStatus OperationalStatus PhysicalLocation FirmwareRevision Persistent memory size Volatile memory size
-------- ----------           ------------ ----------------- ---------------- ---------------- ---------------------- --------------------
1        Intel INVDIMM device Healthy      {Ok}              DIMM 6           102005355        126 GB                 0 GB
1001     Intel INVDIMM device Healthy      {Ok}              DIMM 18          102005355        126 GB                 0 GB
101      Intel INVDIMM device Healthy      {Ok}              DIMM 7           102005355        126 GB                 0 GB
1011     Intel INVDIMM device Healthy      {Ok}              DIMM 16          102005355        126 GB                 0 GB
11       Intel INVDIMM device Healthy      {Ok}              DIMM 4           102005355        126 GB                 0 GB
1101     Intel INVDIMM device Healthy      {Ok}              DIMM 19          100005127        126 GB                 0 GB
111      Intel INVDIMM device Healthy      {Ok}              DIMM 9           102005355        126 GB                 0 GB
1111     Intel INVDIMM device Healthy      {Ok}              DIMM 21          102005355        126 GB                 0 GB
```

Figure 2 Show physical persistent memory devices

2. Return aggregate PMEM regions available for provisioning a logical device

   ```
   PS> Get-PmemUnusedRegion
   ```

   The output is shown in Figure 3.

```
PS C:\ligq> Get-PmemUnusedRegion

RegionId TotalSizeInBytes DeviceId
-------- ---------------- --------
       1     541165879296 {1, 101, 11, 111}
       3     541165879296 {1001, 1101, 1011, 1111}
```

Figure 3 Show available region for DCPMM

3. Create namespaces

   New-PmemDisk creates a new logical PMEM disk based on the free regions you provided. We can combine **Get-PmemUnusedRegion** with this command to create namespaces.

   a. Create a new PMEM disk

      ```
      PS> Get-PmemUnusedRegion 1 | New-PmemDisk
      ```

      Replace 1 with the RegionID. The output of the command is shown in Figure 4.

```
PS C:\ligq> Get-PmemUnusedRegion 1 | New-PmemDisk
Creating new persistent memory disk. This may take a few moments.
```

Figure 4 Create namespace on one region for DCPMM

   b. Create new PMEM disks on all available regions

      ```
      PS> Get-PmemUnusedRegion | New-PmemDisk
      ```

      The output is shown in Figure 5.

```
PS C:\ligq>  Get-PmemUnusedRegion | New-PmemDisk
Creating new persistent memory disk. This may take a few moments.
Creating new persistent memory disk. This may take a few moments.
```

Figure 5 Create namespaces on all available regions for DCPMM

4. Returns one or more logical persistent memory disks

```
PS> Get-PmemDisk
```

The output of the command is shown in Figure 6.

```
PS C:\ligq> Get-PmemDisk

DiskNumber Size   HealthStatus AtomicityType CanBeRemoved PhysicalDeviceIds        UnsafeShutdownCount
---------- ----   ------------ ------------- ------------ -----------------        -------------------
1          504 GB Healthy      None          True         {1, 101, 11, 111}        23
2          504 GB Healthy      None          True         {1001, 1101, 1011, 1111} 23
```

Figure 6 Show logic persistent memory devices

5. Format the DCPMM and create a DAX volume

```
PS> get-disk -Number 1 | Initialize-Disk -PartitionStyle GPT
PS> get-disk -Number 1 | New-Volume -FriendlyName DAX-VOL -DriveLetter D |
Format-volume -Filesystem NTFS -IsDAX $true
```

Replace 1 with the DeviceID and D with the drive letter for the DAX volume. The output is shown in Figure 7.

```
PS C:\ligq> get-disk -Number 1 | Initialize-Disk -PartitionStyle GPT
PS C:\ligq> get-disk -Number 1 | New-Volume -FriendlyName DAX-VOL -DriveLetter D | Format-volume -Filesystem NTFS -IsDAX $true

DriveLetter FriendlyName FileSystemType DriveType HealthStatus OperationalStatus SizeRemaining      Size
----------- ------------ -------------- --------- ------------ ----------------- -------------      ----
D                        NTFS           Fixed     Healthy      OK                      503.9 GB 503.98 GB
```

Figure 7 Create one DAX volume

6. Check if the disk is the DAX mode

```
PS> fsutil.exe fsinfo volumeinfo D:
```

The output of the command is shown in Figure 8.

```
PS C:\ligq> fsutil.exe fsinfo volumeinfo D:
Volume Name :
Volume Serial Number : 0xe6e6fdb3
Max Component Length : 255
File System Name : NTFS
Is ReadWrite
Not Thinly-Provisioned
Supports Case-sensitive filenames
Preserves Case of filenames
Supports Unicode in filenames
Preserves & Enforces ACL's
Supports Disk Quotas
Supports Reparse Points
Returns Handle Close Result Information
Supports POSIX-style Unlink and Rename
Supports Object Identifiers
Supports Named Streams
Supports Hard Links
Supports Extended Attributes
Supports Open By FileID
Supports USN Journal
Is DAX volume
```

Figure 8 Check DAX volume

7. Delete namespace

```
PS> Get-PmemDisk 1 | Remove-PmemDisk
```

This command pipeline will remove a persistent memory disk with Region ID 1. It is important to note that removing a persistent memory disk will result in data loss on that disk. The output is shown in Figure 9

```
PS C:\ligq> Get-PmemDisk 1 | Remove-PmemDisk

This will remove the persistent memory disk(s) from the system and will result in data loss.
Remove the persistent memory disk(s)?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A
Removing the persistent memory disk. This may take a few moments.
```

Figure 9 Delete namespace

8. Clear DCPMM

   ```
   PS> Get-PmemDisk 1 | Get-PmemPhysicalDevice | Initialize-PmemPhysicalDevice
   ```

   This command pipeline will initialize the label storage area on a persistent memory disk with Region ID 1. This can be used to clear corrupted label storage info on the persistent memory devices. It is important to note that this command should be used as a last resort to fix persistent memory related issues. It will result in data loss to the persistent memory.

   The output is shown in Figure 10.

```
PS C:\ligq> Get-PmemDisk 1 | Get-PmemPhysicalDevice | Initialize-PmemPhysicalDevice

This will initialize the label storage area on the physical persistent memory device(s) and will result in data loss.
Initializes the physical persistent memory device(s)?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A
Initializing the physical persistent memory device. This may take a few moments.
Initializing the physical persistent memory device. This may take a few moments.
Initializing the physical persistent memory device. This may take a few moments.
Initializing the physical persistent memory device. This may take a few moments.
```

Figure 10 Initialize physical device for DCPMM

Configure DCPMM by PowerShell scripts PmemTool

The PowerShell scripts PmemTool is developed by Lenovo DCG OS team. You can access it from Github:

https://github.com/lenovo/powershell-pmemtool

It is recommended to create a goal first in UEFI settings before further configurations using the PowerShell scripts PmemTool. The following are example steps (2-way interleaved mode) for the configurations:

1. 1.To show the basic information of pmem disks, such as disk number, healthy

   ```
   PmemTool.ps1 -show
   ```

   Output of the command is shown in Figure 11.

```
PS C:\ligq\PmemTool_v1.1> .\PmemTool.ps1 -show

Number Friendly Name          Serial Number                    HealthStatus        OperationalStatus      Total Size Partition
                                                                                                                     Style
------ -------------          -------------                    ------------        -----------------      ---------- ----------
2      Persistent memory disk 03018089cde7559ab8954448bc992... Healthy             Online                    504 GB GPT
3      Persistent memory disk 03018089de54daf0778a674fa480d... Healthy             Online                    504 GB GPT
```

Figure 11 Display all SCM devices

2. To show the physical information of pmem disks, such as DeviceID, physical location, firmware version, size

   ```
   PmemTool.ps1 -ShowPhysicalInfo
   ```

   The output is shown in Figure 12.

```
PS C:\ligq\PmemTool_v1.1> .\PmemTool.ps1 -ShowPhysicalInfo

DeviceId DeviceType          HealthStatus OperationalStatus PhysicalLocation FirmwareRevision Persistent memory size Volatile memory
-------- ----------          ------------ ----------------- ---------------- ---------------- --------------------- --------------
1        Intel INVDIMM device Healthy      {Ok}              DIMM 6           102005355        126 GB                0 GB
101      Intel INVDIMM device Healthy      {Ok}              DIMM 7           102005355        126 GB                0 GB
11       Intel INVDIMM device Healthy      {Ok}              DIMM 4           102005355        126 GB                0 GB
111      Intel INVDIMM device Healthy      {Ok}              DIMM 9           102005355        126 GB                0 GB
1001     Intel INVDIMM device Healthy      {Ok}              DIMM 18          102005355        126 GB                0 GB
1101     Intel INVDIMM device Healthy      {Ok}              DIMM 19          100005127        126 GB                0 GB
1011     Intel INVDIMM device Healthy      {Ok}              DIMM 16          102005355        126 GB                0 GB
1111     Intel INVDIMM device Healthy      {Ok}              DIMM 21          102005355        126 GB                0 GB
```

Figure 12 Show physical persistent memory devices

3. To make all your pmem disks ready to work with DAX mode

   `PmemTool.ps1 -Ready`

   This command pipeline will create namespaces on all available regions for DCPMM and format them to be DAX volumes. The output is shown in Figure 13.

```
PS C:\ligq\PmemTool_v1.1> .\PmemTool.ps1 -ready
try to create namespace for unused region of pmem device
Creating new persistent memory disk. This may take a few moments.
Creating new persistent memory disk. This may take a few moments.
RAW SCM devices are waiting for the initialization:

DriveLetter FriendlyName FileSystemType DriveType HealthStatus OperationalStatus SizeRemaining      Size
----------- ------------ -------------- --------- ------------ ----------------- -------------      ----
D                        NTFS           Fixed     Healthy      OK                    503.9 GB 503.98 GB
F                        NTFS           Fixed     Healthy      OK                    503.9 GB 503.98 GB
```

Figure 13 Make DCPMM ready for work

4. To remove one pmem disk

   `PmemTool.ps1 -Remove disknum`

   The output is shown in Figure 14.

```
PS C:\ligq\PmemTool_v1.1> .\PmemTool.ps1 -remove 1
This operation will destroy the persistent namespaces from your disk 1
Data will lose if you select Yes or Yes to All in the subsequent pop-up box.

Confirm
Are you sure you want to perform this action?
This will erase all data on disk 1 "Persistent memory disk".
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A

This will remove the persistent memory disk(s) from the system and will result in data loss.
Remove the persistent memory disk(s)?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A
Removing the persistent memory disk. This may take a few moments.
```

Figure 14 Remove one DCPMM volume

5. To remove all pmem disks

   `PmemTool.ps1 -Removeall`

   The output is shown in Figure 15.

```
PS C:\ligq\PmemTool_v1.1> .\PmemTool.ps1 -removeall
This operation will destroy the persistent namespaces from your disk
Data will lose if you select Yes or Yes to All in the subsequent pop-up box.

Confirm
Are you sure you want to perform this action?
This will erase all data on disk 1 "Persistent memory disk".
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A

This will remove the persistent memory disk(s) from the system and will result in data loss.
Remove the persistent memory disk(s)?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A
Removing the persistent memory disk. This may take a few moments.

Confirm
Are you sure you want to perform this action?
This will erase all data on disk 1 "Persistent memory disk".
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A

This will remove the persistent memory disk(s) from the system and will result in data loss.
Remove the persistent memory disk(s)?
[Y] Yes  [A] Yes to All  [N] No  [L] No to All  [S] Suspend  [?] Help (default is "Y"): A
Removing the persistent memory disk. This may take a few moments.
```

Figure 15 Remove all DCPMM volumes

6. To get the help about this tool

   `PmemTool.ps1 -Help`

   The output of this command is shown in Figure 16.

```
PS C:\ligq> cd .\PmemTool_v1.1\
PS C:\ligq\PmemTool_v1.1> .\PmemTool.ps1 -help
################################################################################
Please use this tool on Windows Server 2019 to manage your pmem disk:
To show the basic information of pmem disks   , usage: PmemTool.ps1 -Show
To show the physical information of pmem disks, usage: PmemTool.ps1 -ShowPhysicalInfo
To make all your pmem disks ready to be use,    usage: PmemTool.ps1 -Ready
To remove one pmem disk,                        usage: PmemTool.ps1 -Remove disknum
To remove all pmem disks,                       usage: PmemTool.ps1 -Removeall
To get the version of this tool,                usage: PmemTool.ps1 -Version
################################################################################
```

Figure 16 Output of the help command

DCPMM Status Checking in different modes

DCPMM status can be checked by Device Manager and Task Manager. In Device Manager, you can check if Windows Server identifies all the DCPMMs successfully or if all the DCPMMs work. In Task Manager, you can check what the capacity of total memory and available memory is respectively and if the number is correct.

Memory mode

In this section, we will show what DCPMM in Memory Mode looks like in Device Manager and Task Manager.

1. Check our DCPMM device In Device Manager.

   Figure 17 shows eight DCPMMs working in memory mode.

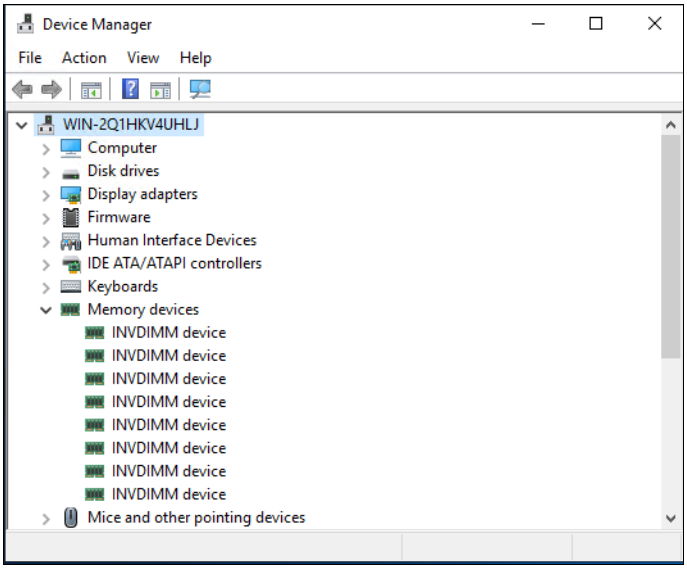

Figure 17 DCPMM in memory mode in Device Manager

2. Check our DCPMM device in Task Manager

   In Task Manager for this mode, Windows shows the customer the total capacity of DRAM and DCPMM though DRAM acts as the cache of DCPMM, not DCPMM only. This is Windows behavior.

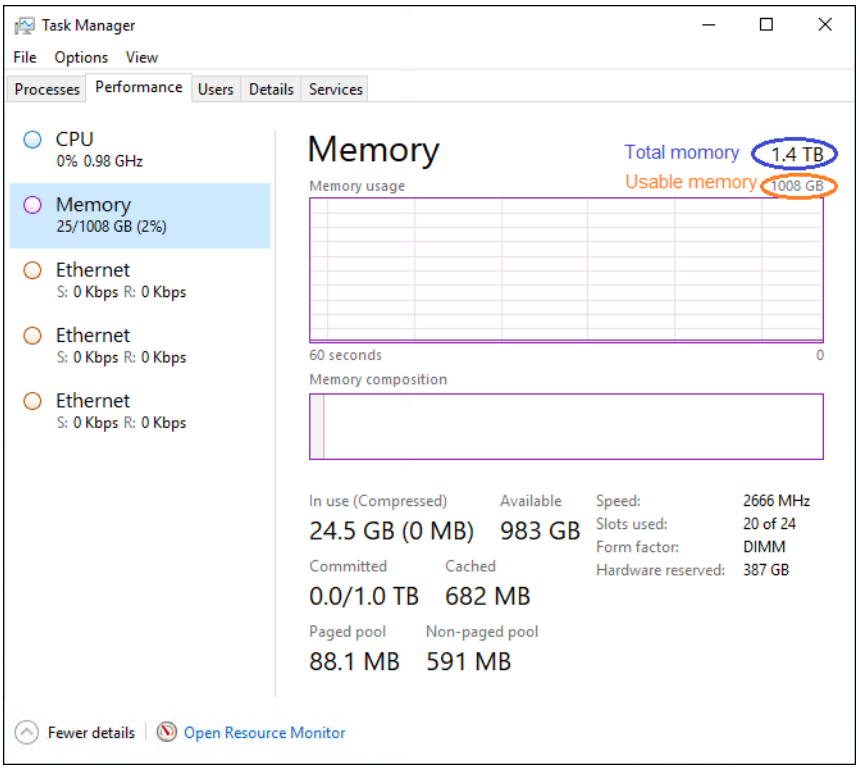

Figure 18 DCPMM in memory mode in Task Manager

In Figure 18, we have twelve 32GB DRAM and eight 128GB DCPMM configured. You can find that the total memory is 1.4 TB (the capacity of DRAM and DCPMM) marked with blue while the available memory is 1008 GB (the capacity of DCPMM) marked with orange.

App Direct mode

In this section, we will show what DCPMM in App Direct mode looks like in Device Manager and Task Manager.

1. Check our DCPMM device in Device Manager
   - Interleaved mode

     Figure 19 on page 13 shows 8 DCPMMs working in App Direct interleaved mode in SR650 servers. SR650 servers have two processors so there are two interleaved persistent memory disks.

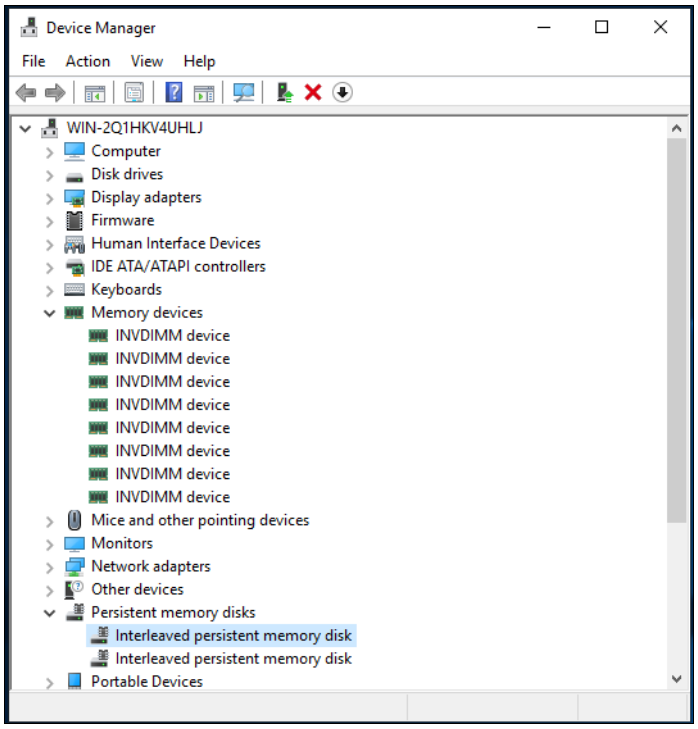

Figure 19 DCPMM in App Direct interleaved mode in Device Manager

   - Non-interleaved mode

     Figure 20 on page 14 shows eight DCPMMs working in App Direct non-interleaved mode in SR650 servers. You can get the difference from display of persistent memory disks between interleaved mode and non-interleaved mode.

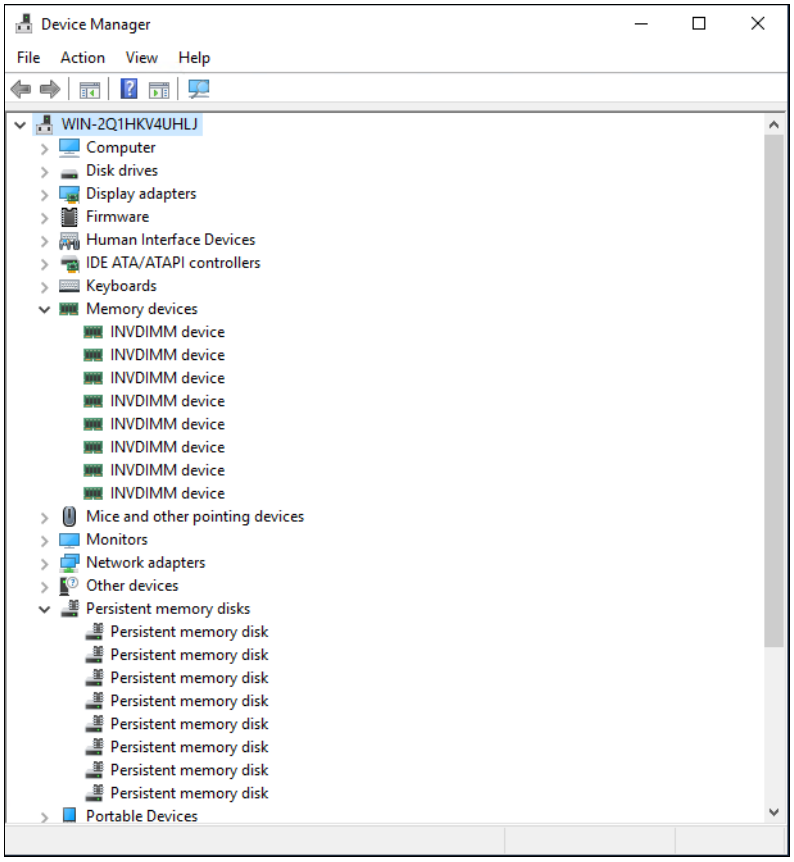

Figure 20 DCPMM in App Direct non-interleaved mode in Device Manager

2. Check our DCPMM device in Task Manager

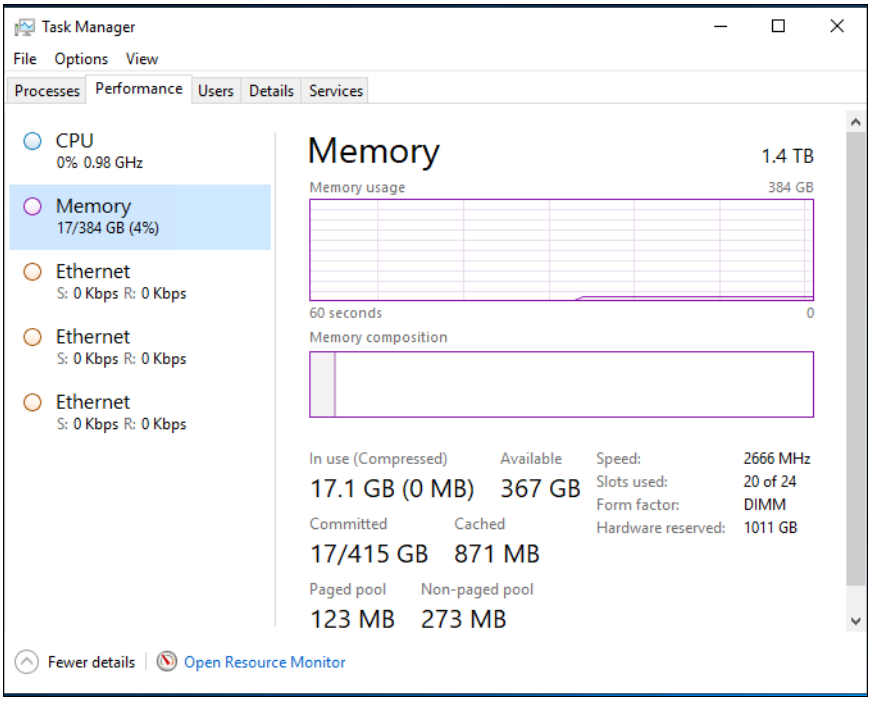

Figure 21 DCPMM in App Direct mode in Task Manager

Mixed mode

In this section, we will show what DCPMM in Mixed Mode looks like in Device Manager and Task Manager.

1. Check our DCPMM device in Device Manager

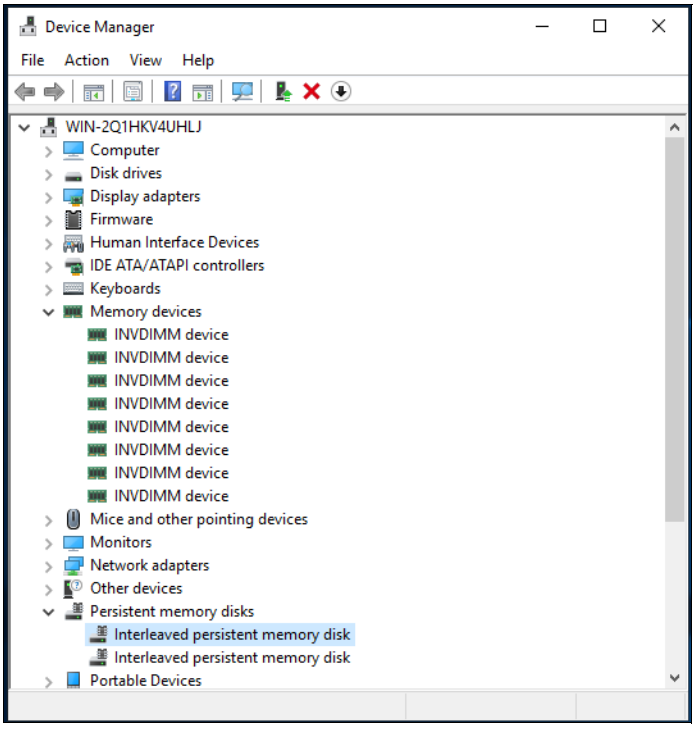

Figure 22 DCPMM in mixed mode in Device Manager

2. Check our DCPMM device in Task Manager

   For this mode, you need to specify the percentage of the DCPMM total capacity will be allocated to Memory Mode. You can get the allowed percentage for each DCPMM part number from https://lenovopress.com/lp1066#Mixed-Mode-requirements.

   In Figure 23 on page 16, we used 75% of DCPMMs to work in memory mode while the remaining capacity of the DCPMMs for App Direct mode.

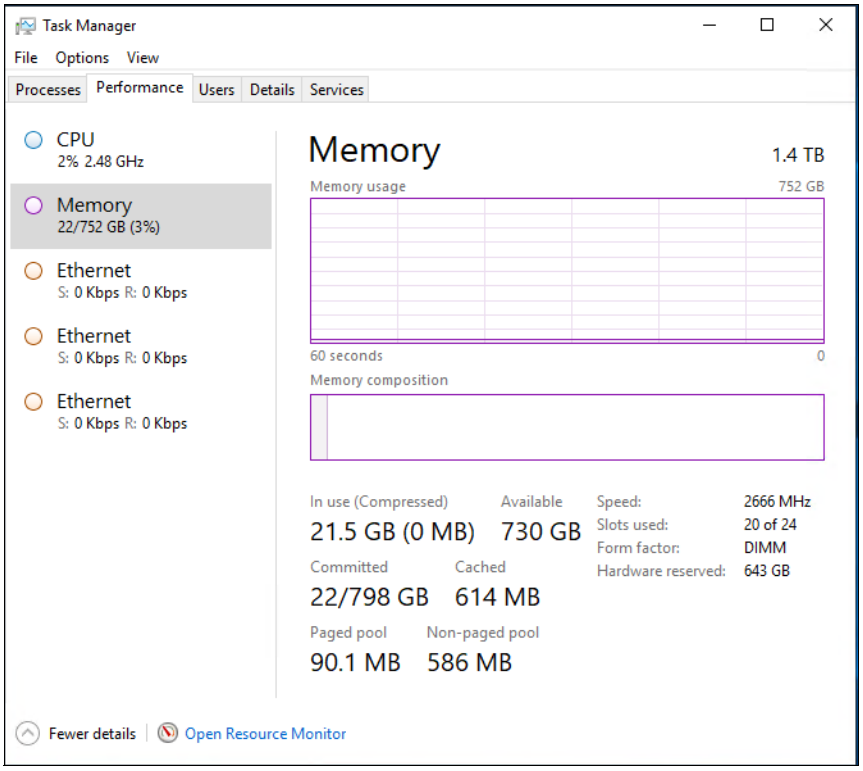

Figure 23 DCPMM in mixed mode in Task Manager

References

Review the following web pages for more information:

- Microsoft web page for persistent memory deployment

  https://docs.microsoft.com/en-us/windows-server/storage/storage-spaces/deploy-pmem

- Intel Optane DC Persistent Memory web page

  https://www.intel.com/content/www/us/en/architecture-and-technology/optane-dc-persistentmemory.html

- Lenovo Press paper, Intel Optane DC Persistent Memory Product Guide

  https://lenovopress.com/lp1066

- SNIA web page for persistent memory

  https://www.snia.org/sites/default/files/PM-Summit/2018/presentations/04_B_PM_Summit_18_Christiansen_Final_Post.pdf

- SNIA web page for persistent memory

  https://www.snia.org/sites/default/files/PM-Summit/2018/presentations/06_PM_Summit_2018_Talpey-Final_Post-CORRECTED.pdf

Change history

October 16, 2021:

- Correction to a command in “vPMEM (virtual persistent memory) support” on page 5

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