Lenovo

Enabling Intel Optane DC Persistent Memory on Lenovo ThinkSystem Servers

Introduces the new DCPMMs for Lenovo servers

Explains the Lenovo tools to performance management functions

Describes operating system support and OS-supplied tools

Describes the tools availalble for heath checking and diagnostics

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Abstract

Lenovo has engineered ThinkSystem servers incorporating second-generation Intel Xeon Scalable processors to take advantage of features provided by Intel Optane DC Persistent Memory.

This paper describes the overall implementation of DC Persistent Memory Modules (DCPMMs) on Lenovo ThinkSystem. The paper describes the supported modes, the population requirements when both DDR4 DIMMs and DCPMMs are installed, the health monitoring features and both out-of-band and in-band management of DCPMMs.

This paper assumes that the reader is familiar with standard server memory DIMMs and how DIMMs are typically used in servers. The reader will learn how to use Intel DCPMMs as storage as well as volatile memory on a Lenovo ThinkSystem server.

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Introduction

Intel Optane DC Persistent Memory was announced along with the second-generation Intel Xeon Scalable Processors in 2019. DC Persistent Memory Modules (DCPMM) are next-generation memory modules that introduced Optane Media technology in a DDR4 form factor. DCPMMs have the form factor of a standard DDR4 DIMM with full-length heat spreader. Figure 1 shows an Intel DC Persistent Memory Module
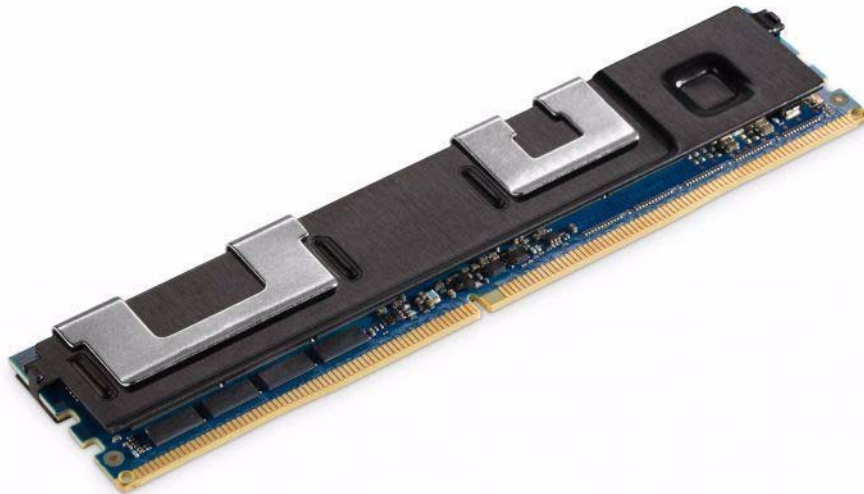

Figure 1   Intel DC Persistent Memory Module

Supported operating modes are Memory Mode (volatile) and App Direct Memory mode (persistent memory). Users can also configure DCPMM as a Block storage device using NVDIMM device drivers, while DCPMM is configured in App Direct Mode.

Intel DCPMMs are available in 128GB, 256GB and 512 GB capacities, and are capable of running at a maximum speed of 2666 MT/s.

Modes of operation

DCPMMs support two modes of operation;

► Memory Mode (also known as 2LM)
► Persistent Memory Mode (also known as PM or App Direct)

Users can configure DCPMM into mixed mode, to enable both modes of operation at the same time (that is, a portion of the DCPMM is used in Memory Mode, while the rest is used in Persistent Mode).

Memory mode

Memory mode has the following characteristics:

► In this mode, DCPMM functions like a standard DDR4 memory

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- ► Memory mode provides for large memory capacity at lower cost but at a lower performance than standard DRAMs.
- ► DDR4 standard DRAM DIMMs (henceforth referred to as DIMMs) are still required for normal system usage. DIMMs in system are used as cache for DCPMMs. See "Population rules" on page 8 for details.
- ► Software/Application changes are not required, but there could be OS enablement dependency. See "Operating system support" on page 18.

Like a standard DIMM, the data is volatile in Memory mode. The encryption key used to encrypt the data is cleared upon power cycle which ensures data volatility.

App Direct Mode (Persistent Mode)

App Direct Mode has the following characteristics:

- ► In App Direct mode, data written to the DCPMM is persistent across power cycle and resets. This is similar to NVDIMM_N operation, but unlike NVIDMM-N, DCPMM does not require any backup energy source.
- ► App Direct mode allows the application to directly read/write NVM address space without a driver. Applications will have to be modified and tuned for this mode. This is again similar to NVDIMM-N
- ► Data at rest in the DCPMM is encrypted and access is restricted via user passphrase if end-user enables security.

Storage over App Direct

In this mode, the DCPMMs are still configured in App Direct mode but NVDIMM driver allows the applications use the Persistent memory as a Block device

- ► DCPMM operates in Blocks like SSD/HDD
- ► Support traditional read/write
- ► Support 512B and 4KB Block under Linux
- ► Support only 4KB Block under Windows

Figure 2 on page 7 shows how an unchanged application uses the DCPMM as a storage device. DCPMMs should be configured in App Direct mode by UEFI.
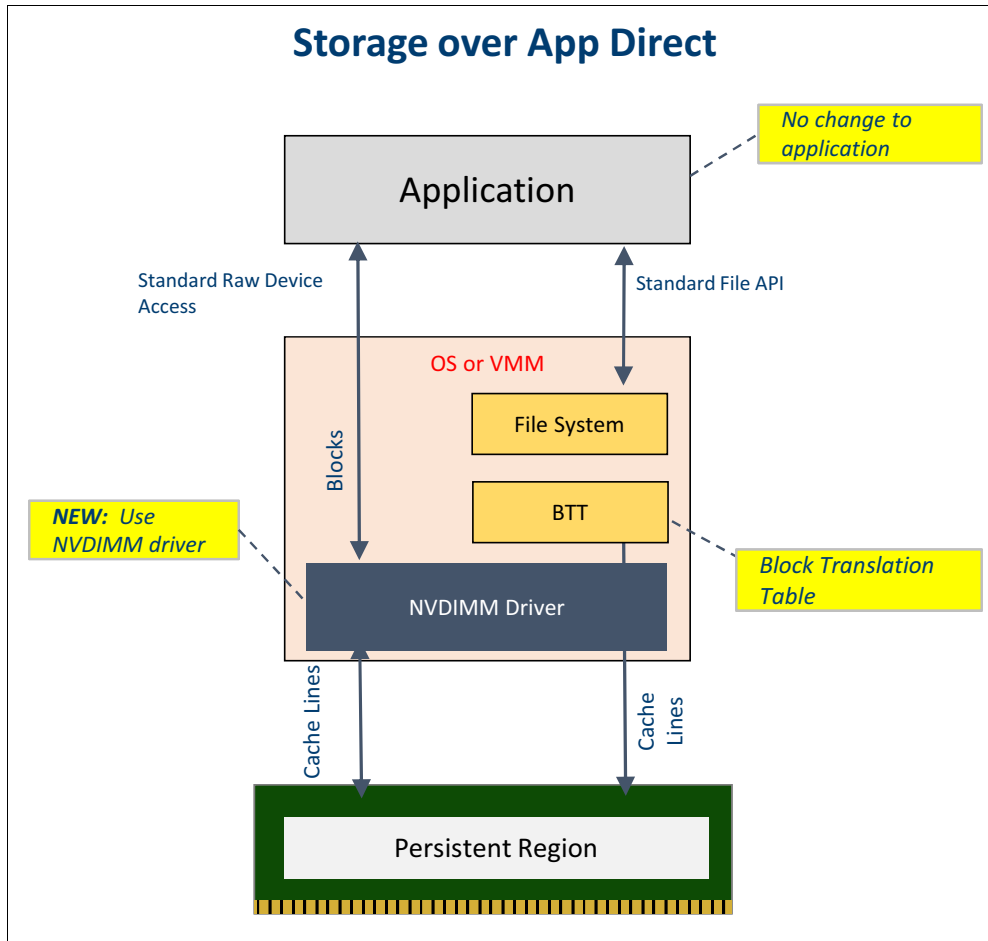
Storage over App Direct

Figure 2   Storage Over App Direct

DCPMM Support on ThinkSystem servers

Intel DCPMM is supported on many of the Lenovo ThinkSystem servers. Table 1 lists the scope of support.

Table 1   DCPMM support scope on Lenovo ThinkSystem

Server model	Number of memory slots supported	Max number of DCPMM supported	Available capacities (GB)	Modes supported
SR950	96	48	128, 256, 512	Memory, App Direct, Mixed
SR860	48	24	128, 256, 512	Memory, App Direct, Mixed
SR850	48	24	128, 256, 512	Memory, App Direct, Mixed
SD650	16	4	128, 256, 512	Memory, App Direct, Mixed
SD530	16	4	128,256,512	Memory, App Direct, Mixed
SN850	48	24	128, 256, 512	Memory[a]
SN550	24	12	128, 256, 512	Memory[a]

Server model	Number of memory slots supported	Max number of DCPMM supported	Available capacities (GB)	Modes supported
SR650	24	12	128, 256, 512	Memory, App Direct, Mixed
SR630	24	12	128, 256, 512	Memory, App Direct, Mixed
SR590	16	4	128, 256, 512	Memory, App Direct, Mixed
SR570	16	4	128, 256, 512	Memory, App Direct, Mixed

a. The SN850 and SN550 only support App Direct Mode and Mixed Mode under special bid conditions.

Memory Configurator

The memory configuration utility in Lenovo's Data Center Solution Configurator (DCSC) should always be used to determine the optimal DCPMM / DIMM configuration. The configurator uses the population rules and suggests valid DIMM / DCPMM configurations, per user inputs.

The memory configurator is located at:

https://dcsc.lenovo.com/#/memory_configuration

The memory configurator will help users choose a memory / DCPMM configuration based on user-input, such as system, number of CPUs, memory capacity, App Direct capacity and mode (performance or cost). The memory configurator will produce DIMM / DCPMM configuration options based on best price or best performance criteria. Once the user has completed their configuration, the configurator will link the configuration to our manufacturing process.

Population rules

The rules for configuring DCPMMs are as follows:

► DCPMM is supported with selected SKUs of second generation of Intel® Xeon® Scalable processors:
  – All Platinum processors
  – All Gold processors
  – Silver 4215 processor
► Systems can support 16GB, 32GB, 64GB,128GB and 256GB DIMM and DCPMM together
► When DCPMM is configured in Memory Mode or Mixed Mode, the ratio of DDR4 Memory to Persistent Memory must be between 1:4 and 1:16. This ratio is not applicable to App Direct mode of DCPMM
► The processor must support the total amount of memory installed - both DDR4 memory and persistent memory.
  – "L" SKU CPU is required to support memory capacity up to 4.5TB.
  – "M" SKU CPU is required to support memory capacity up to 2.0TB.
  – All other SKUs can support only up to 1.0TB

- ▶ Mode supported:
  - – 100% Memory Mode;
  - – 100% App Direct interleaved mode, 100% App Direct non-interleaved mode
  - – Mixing Memory Mode and App Direct interleaved/non-interleaved Mode with percentages. In this mode, volatile and persistent capacity will be aligned to 32GiB boundary
- ▶ Within a server, populate identical DIMMs and identical DCPMM for individual population That is, use only one Lenovo part number for DIMMs and one Lenovo part number for DCPMMs.
- ▶ All the DCPMMs in the system must be configured identically. Configuration include mode (memory mode, App Direct or mixed) and capacity in each mode.
- ▶ The matrix in Figure 3 represents all validated DCPMM configuration
  - – A system that supports 2-2-2 (that is two memory slots per channel and 12 memory sockets per processor) can support all configurations listed below. Systems that support 2-2-2 are SR950, SR860, SR850, SR650, SR630, SN880 and SN550
  - – A system that support 2-1-1 (i.e. 8 DIMM sockets per processor) can support only 2-1-1 configurations. Systems that support 2-1-1 configurations are SD650, SD530, SR590 and SR570.
  - – Some systems (SD530, SR650, and SR630) limit CPUs that can be used with DCPMM due to the size of CPU heat sink.

Symmetric Population within the Socket												
	iMC1						iMC0					
	Channel 2		Channel 1		Channel 0		Channel 2		Channel 1		Channel 0		
Modes	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	
AD	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	2-2-2
MM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	2-2-2
AD + MM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	DCPMM	DIMM	2-2-2
AD	–	DIMM	–	DIMM	DCPMM	DIMM	–	DIMM	–	DIMM	DCPMM	DIMM	2-1-1
MM	–	DIMM	–	DIMM	DCPMM	DIMM	–	DIMM	–	DIMM	DCPMM	DIMM	2-1-1
AD + MM	–	DIMM	–	DIMM	DCPMM	DIMM	–	DIMM	–	DIMM	DCPMM	DIMM	2-1-1
AD	–	DIMM	DCPMM	DIMM	DCPMM	DIMM	–	DIMM	DCPMM	DIMM	DCPMM	DIMM	2-2-1
MM	–	DIMM	DCPMM	DIMM	DCPMM	DIMM	–	DIMM	DCPMM	DIMM	DCPMM	DIMM	2-2-1
AD + MM	–	DIMM	DCPMM	DIMM	DCPMM	DIMM	–	DIMM	DCPMM	DIMM	DCPMM	DIMM	2-2-1
AD	–	DCPMM	–	DIMM	–	DIMM	–	DCPMM	–	DIMM	–	DIMM	1-1-1
MM	–	DCPMM	–	DIMM	–	DIMM	–	DCPMM	–	DIMM	–	DIMM	1-1-1
AD + MM	–	DCPMM	–	DIMM	–	DIMM	–	DCPMM	–	DIMM	–	DIMM	1-1-1
AD	–	DCPMM	DIMM	DIMM	DIMM	DIMM	–	DCPMM	DIMM	DIMM	DIMM	DIMM	2-2-1

Asymmetric Population within the Socket												
	iMC1						iMC0					
	Channel 2		Channel 1		Channel 0		Channel 2		Channel 1		Channel 0		
Modes	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	Slot 1	Slot 0	
AD	–	DIMM	–	DIMM	–	DIMM	–	DIMM	–	DIMM	DCPMM	DIMM	2/1-1-1
AD*	–	DIMM	–	DIMM	–	DIMM	–	DIMM	–	DIMM	DCPMM	DIMM	2/1-1-1

* 2nd socket has no DCPMM DIMM

Figure 3   Lenovo supported DIMM/DCPMM population matrix

Managing DCPMMs in ThinkSystem servers

This section describes the ways that DCPMMs are managed using Lenovo ThinkSystem management tools.

Management tasks are as follows:

► "DCPMM inventory"
► "DCPMM configuration" on page 14
► "DCPMM firmware updates and monitoring" on page 16

DCPMM inventory

Lenovo ThinkSystem servers support DCPMM inventory through these management tools:

► "Lenovo XClarity Provisioning Manager (LXPM)"
► "Lenovo XClarity Controller (XCC)" on page 10
► "Lenovo XClarity Essentials (LXCE) OneCLI" on page 13
► "Lenovo XClarity Administrator (LXCA)" on page 14

Lenovo XClarity Provisioning Manager (LXPM)

Press F1 during system boot when prompted, then select **UEFI Setup** → **System Settings** → **Intel Optane DCPMMs** → **Intel Optane DCPMMs** Details. DCPMM related inventory info is displayed. Figure 4 on page 10 shows an example.
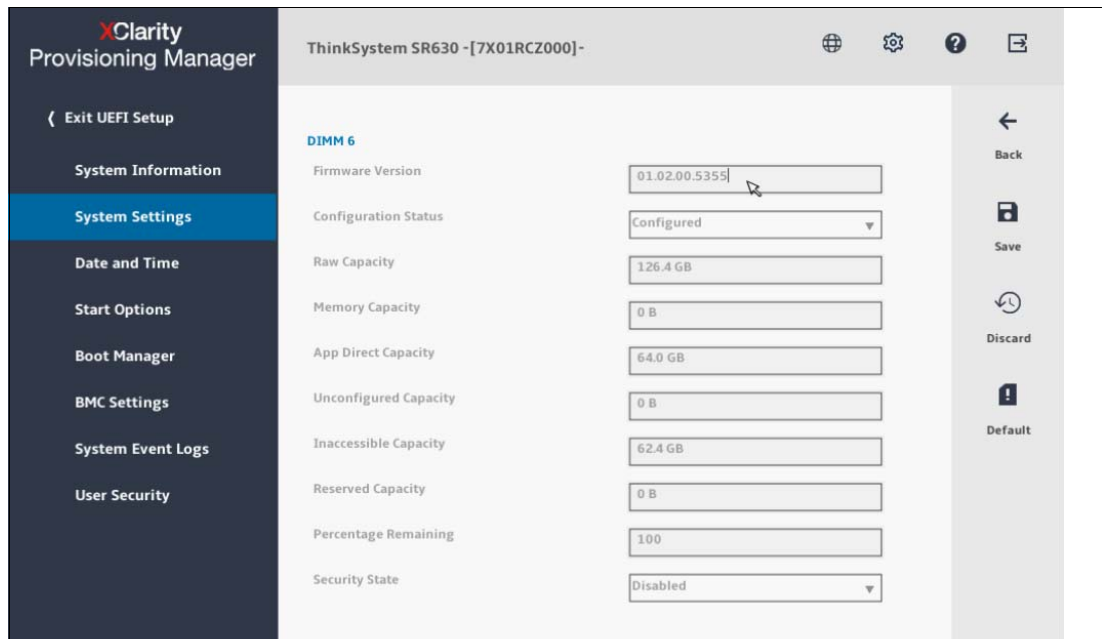

Figure 4   DCPMM Inventory in Lenovo XClarity Provisioning Manager

Lenovo XClarity Controller (XCC)

With the server powered (does not need to be booted), you can access the remote web management interface of XCC by opening a web browser to the XCC IP address. Click Inventory and select one DCPMM DIMMs, as shown in Figure 5.

Figure 5   DCPMM Inventory via Lenovo XClarity Controller

DCPMM inventory is also supported thru the XCC Redfish interface with the standard Memory and SoftwareInventory schema. Details can be found in the XCC Redfish REST API Guide on the Lenovo support site:

https://sysmgt.lenovofiles.com/help/index.jsp?topic=%2Fcom.lenovo.systems.management.xcc.doc%2Fprintable_doc.html&cp=2_0&anchor=printable_doc

Example 1 shows the DCPMM JSON properties returned from the Redfish API.

Example 1   Redfish JSON properties for DCPMMs

```
{
    "AllowedSpeedsMHz": [
        2666
    ],
    "VolatileRegionSizeLimitMiB": 0,
    "MemoryDeviceType": "DDR4",
    "Id": "6",
    "MemorySubsystemControllerProductID": "0x8980",
    "Links": {
        "Chassis": {
            "@odata.id": "/redfish/v1/Chassis/1"
        }
    },
    "MemoryMedia": [
        "DRAM"
    ],
    "PartNumber": "NMA1XBD128GQS",
    "DeviceID@Redfish.Deprecated": "The property is deprecated. Please use ModuleProductID instead.",
    "MemoryLocation": {
        "Channel": 0,
        "MemoryController": 0,
        "Slot": 6,
        "Socket": 1
    },
    "MemorySubsystemControllerManufacturerID": "0x097a",
    "MemoryType": "IntelOptane",
    "DeviceLocator": "DIMM 6",
    "CacheSizeMiB": null,
    "Oem": {
        "Lenovo": {
            "@odata.type": "#LenovoMemory.v1_0_0.LenovoMemory",
```

```
            "PN": "02JG167"
        }
    },
    "@odata.type": "#Memory.v1_7_0.Memory",
    "RankCount": 8,
    "SubsystemDeviceID@Redfish.Deprecated": "The property is deprecated. Please use
MemorySubsystemControllerProductID instead.",
    "DeviceID": "DIMM_6",
    "VendorID": "Intel",
    "Regions": [
        {
            "SizeMiB": 129024,
            "RegionId": "AppDirect",
            "MemoryClassification": "ByteAccessiblePersistent"
        },
        {
            "SizeMiB": 432,
            "RegionId": "Inaccessible",
            "MemoryClassification": "Block"
        }
    ],
    "ModuleProductID": "0x4151",
    "@odata.id": "/redfish/v1/Systems/1/Memory/6",
    "LogicalSizeMiB": 129024,
    "@odata.context": "/redfish/v1/$metadata#Memory.Memory",
    "DataWidthBits": 64,
    "@odata.etag": "\"828705dee0ff7bbe1c207b5c7f1ffb61\"",
    "SerialNumber": "00001510",
    "VendorID@Redfish.Deprecated": "The property is deprecated. Please use ModuleManufacturerID instead.",
    "SecurityCapabilities": {},
    "CapacityMiB": 131072,
    "Description": "This resource is used to represent a memory for a Redfish implementation.",
    "SubsystemVendorID@Redfish.Deprecated": "The property is deprecated. Please use
MemorySubsystemControllerManufacturerID instead.",
    "Location": {
        "PartLocation": {
            "LocationType": "Slot",
            "ServiceLabel": "DIMM 6",
            "LocationOrdinalValue": 5
        }
    },
    "SubsystemDeviceID": "0x097a",
    "NonVolatileSizeMiB": 129024,
    "Status": {
        "State": "Enabled",
        "Health": "OK"
    },
    "OperatingMemoryModes": [
        "Volatile"
    ],
    "BusWidthBits": 72,
    "ModuleManufacturerID": "0x8980",
    "Manufacturer": "Intel",
    "SubsystemVendorID": "0x8980",
    "OperatingSpeedMhz": 2666,
    "BaseModuleType": "LRDIMM",
    "Name": "DIMM 6",
    "PersistentRegionSizeLimitMiB": 129024,
    "VolatileSizeMiB": 131072,
    "FunctionClasses": [
```

```
        "Volatile"
    ]
}
```

Lenovo XClarity Essentials (LXCE) OneCLI

The OneCLI inventory command can be used to get DCPMM inventory information. The following command generates an HTML-formatted report you can view in a web browser:

```
OneCli.exe inventory getinfor --htmlreport
```

Click on the link **Persistent Memory** under Hardware on the left side to view detailed DCPMM inventory information, as shown in Figure 6.

Figure 6   DCPMM information from the OneCLI inventory report

Lenovo XClarity Administrator (LXCA)

XClarity Administrator provides detailed DCPMM inventory info by clicking Inventory details. Figure 7 on page 14 shows an example of an installed 256GB DCPMM.

Figure 7   DCPMM inventory in Lenovo XClarity Administrator

DCPMM configuration

Lenovo ThinkSystem servers support DCPMM configuration through these tools:

- ► "Lenovo XClarity Provisioning Manager (LXPM)"
- ► "Lenovo XClarity Essentials (LXCE) OneCLI" on page 15
- ► "Lenovo XClarity Administrator (LXCA)" on page 16

Lenovo XClarity Provisioning Manager (LXPM)

The setup page for DCPMMs in LXPM has the menu structure shown in Figure 8
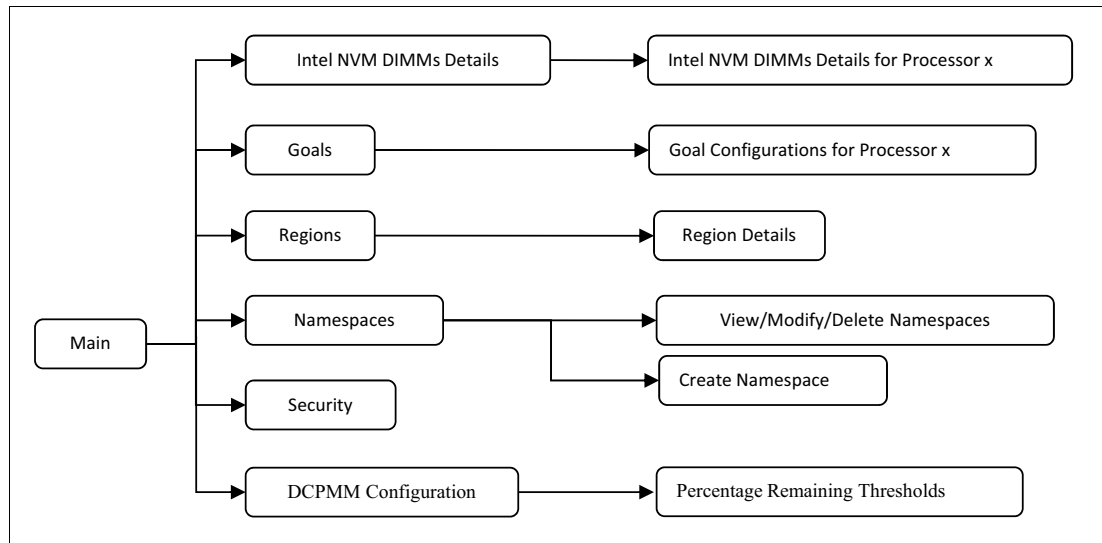

Figure 8   LXPM Setup Page Topography

When prompted during boot, press F1 to launch LXPM. Select **UEFI Setup** → **System Settings** → **Intel Optane DCPMMs**. You will then see the DCPMM related settings as shown in Figure 9 on page 15.
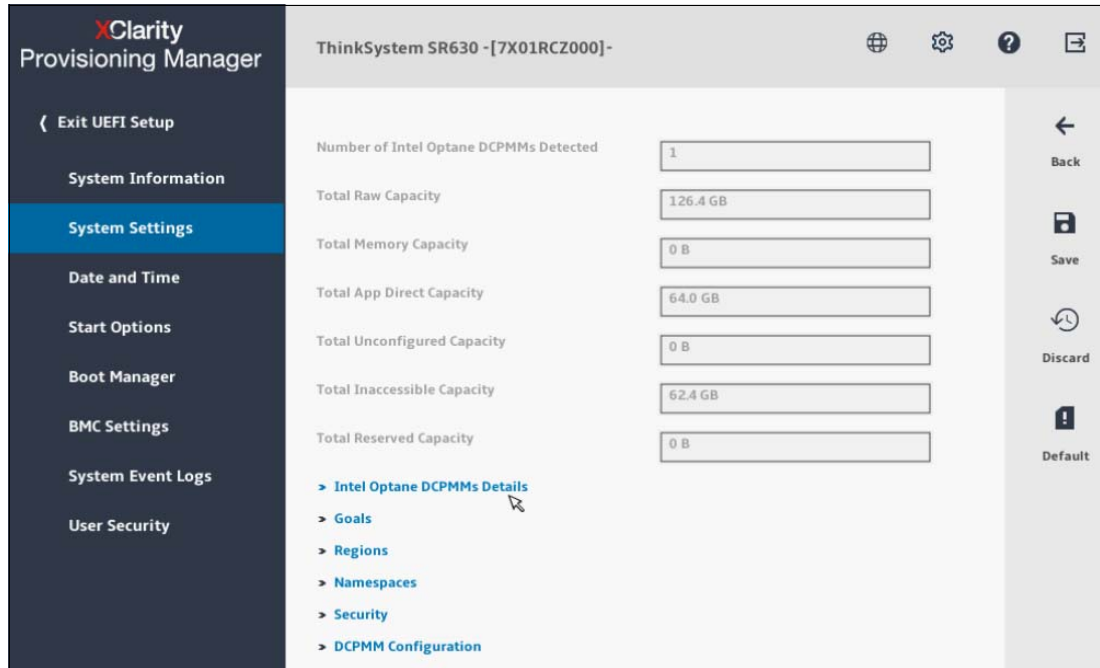
Figure 9   LXPM DCPMM settings (ThinkSystem SR630)

Lenovo XClarity Essentials (LXCE) OneCLI

OneCLI 2.5.0 or later supports DCPMM. The `show` command displays all available settings for DCPMMs:

```
./OneCli config show IntelOptaneDCPMM --bmc USERID:password@bmc_ip
```

Example output of the show command is shown in Figure 10

```
Invoking SHOW command ...
Connected to BMC at IP address 10.240.194.229 by IPMI
IntelOptaneDCPMM.CreateGoal=No
IntelOptaneDCPMM.MemoryModePercentage=0
IntelOptaneDCPMM.PersistentMemoryType=App Direct
IntelOptaneDCPMM.TotalRawCapacity=505.6 GB
IntelOptaneDCPMM.TotalMemoryCapacity=248.0 GB
IntelOptaneDCPMM.TotalAppDirectCapacity=256.0 GB
IntelOptaneDCPMM.PercentageRemainingThresholds=10
IntelOptaneDCPMM.RegionID.1=0x0001
IntelOptaneDCPMM.RegionID.2=0x0002
IntelOptaneDCPMM.RegionSocket.1=Processor 1
IntelOptaneDCPMM.RegionSocket.2=Processor 2
IntelOptaneDCPMM.RegionCapacity.1=128.0 GB
IntelOptaneDCPMM.RegionCapacity.2=128.0 GB
IntelOptaneDCPMM.RegionType.1=App Direct
IntelOptaneDCPMM.RegionType.2=App Direct
IntelOptaneDCPMM.SecurityState=Disabled
IntelOptaneDCPMM.SecurityOperation=None
IntelOptaneDCPMM.DcpmmLocation.1=DIMM 1
IntelOptaneDCPMM.DcpmmLocation.2=DIMM 12
IntelOptaneDCPMM.DcpmmLocation.3=DIMM 13
IntelOptaneDCPMM.DcpmmLocation.4=DIMM 24
IntelOptaneDCPMM.DcpmmUid.1=8089-A2-1835-000020AE
IntelOptaneDCPMM.DcpmmUid.2=8089-A2-1835-00001C52
IntelOptaneDCPMM.DcpmmUid.3=8089-A2-1835-000020C9
IntelOptaneDCPMM.DcpmmUid.4=8089-A2-1835-00001BBA
IntelOptaneDCPMM.DcpmmSecurityState.1=Disabled
IntelOptaneDCPMM.DcpmmSecurityState.2=Disabled
IntelOptaneDCPMM.DcpmmSecurityState.3=Disabled
IntelOptaneDCPMM.DcpmmSecurityState.4=Disabled
IntelOptaneDCPMM.DcpmmAutoUnlockState.1=Not Applicable
IntelOptaneDCPMM.DcpmmAutoUnlockState.2=Not Applicable
IntelOptaneDCPMM.DcpmmAutoUnlockState.3=Not Applicable
IntelOptaneDCPMM.DcpmmAutoUnlockState.4=Not Applicable
Success.
```

Figure 10   OneCLI show command

Lenovo XClarity Administrator (LXCA)

Configure DCPMM in XClarity Administrator by clicking **LXCA Provisioning** →
Configuration Pattern. Figure 11 shows an example.
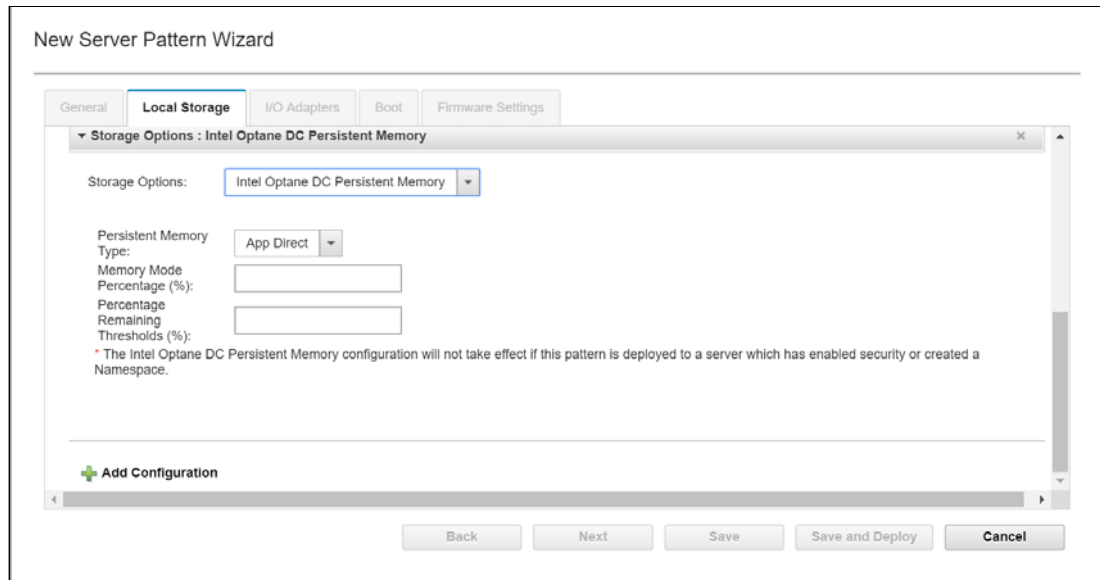
Figure 11   DCPMM Configuration in LXCA

DCPMM firmware updates and monitoring

This section describes the Lenovo tools that provide ways to manage the DCPMM firmware.

► "Updating firmware using OneCLI" on page 17
► "Updating firmware using Lenovo XClarity Administrator" on page 18

Rules and recommendations about DCPMM firmware:

► Each DCPMM has on-DIMM firmware.

► All DCPMMs in the system must be at the same firmware level.

► DCPMM firmware should not be down-leveled unless as guided by Lenovo support
  personnel.

► Configure-to-order server builds with DCPMMs will be flashed to the latest firmware,
  however for field upgrades using option part numbers, you should update all installed
  DCPMMs to the latest firmware level. At the very least, all firmware levels must be the
  same.

Lenovo tools and update bundles support DCPMM firmware updates.

The firmware on DCPMMs can be updated in-band running on an installed OS (such as
Windows Server, RHEL and SLES). Updates will work as either a standalone update or as
part of an UpdateXpress Service Pack (UXSP).

The firmware can also be completed with Lenovo XClarity Essentials (LXCE) Bootable Media
Creator (BoMC) created with a updated ISO, USB Key or PXE, as well as with Lenovo
XClarity Administrator (LXCA), LXCE OneCLI, or LXCE UpdateXpress. Servers running
VMware ESXi will require an out-of-band update.

DCPMM firmware updates for each support server are available from the Lenovo support site:

https://datacentersupport.lenovo.com

Updating firmware using OneCLI

OneCLI 2.5.0 or later will support DCPMM firmware acquisition, scan, version comparison, and update, using the following commands:

```
./OneCli update acquire --ostype platform --mt xxxx --dir /path/to/workingfolder/

./OneClI update scan --bmc bmcuser:bmcpassword@bmcip

./OneCliI update compare --bmc bmcuser:bmcpassword@bmcip --dir
/path/to/workingfolder/

./OneCliI update flash --platform --bmc bmcuser:bmcpassword@bmcip --dir
/path/to/workingfolder/ --sftp
sftpuser:sftppassword@sftpip/path/to/workingfolder_with_rw_permission/
```

Figure 12 shows the result of a scan.


```
                                  Scan Result:
================================================================================
| No. |                Updatable Unit               | Slot | Installed Version |
--------------------------------------------------------------------------------
| 1   | XCC Firmware                                 | N/A  | TEI341S-2.40      |
--------------------------------------------------------------------------------
| 2   | XCC Backup Firmware                          | N/A  | TEI341S-2.40      |
--------------------------------------------------------------------------------
| 3   | UEFI Firmware/BIOS                           | N/A  | IVE135S-2.10      |
--------------------------------------------------------------------------------
| 4   | LXPM Diagnostic Software                     | N/A  | PDL119E-1.60      |
--------------------------------------------------------------------------------
| 5   | LXPM Windows Drivers                         | N/A  | PDL310P-1.10      |
--------------------------------------------------------------------------------
| 6   | LXPM Linux Drivers                           | N/A  | PDL215P-1.40      |
--------------------------------------------------------------------------------
| 7   | QLGC Fibre Channel Adapter L0SPP Software Bundle | N/A | 1.90.53       |
--------------------------------------------------------------------------------
| 8   | EMLX Fibre Channel Adapter N000S Software Bundle(1) | N/A | 11.4.329.13 |
--------------------------------------------------------------------------------
| 9   | EMLX Fibre Channel Adapter N000S Software Bundle(2) | N/A | 11.4.329.13 |
--------------------------------------------------------------------------------
| 10  | MLNX Ethernet Adapter B000A Software Bundle  | N/A  | 2.42.5032         |
--------------------------------------------------------------------------------
| 11  | MLNX Ethernet Adapter B000A UEFI            | N/A  | 14.11.84          |
--------------------------------------------------------------------------------
| 12  | QLogic QML2692 Mezz 16Gb 2-Port Fibre Channel Adapter | 1 | 1.90.53    |
--------------------------------------------------------------------------------
| 13  | Emulex LPm16004B-L Mezz 16Gb 4-Port Fibre Channel Adapter | 2 | 11.4.329.13 |
--------------------------------------------------------------------------------
| 14  | Mellanox ConnectX-3 Mezz FDR 2-Port InfiniBand Adapter (Mellanox Base Firmware) | 4 | 2.42.5032 |
--------------------------------------------------------------------------------
| 15  | Mellanox ConnectX-3 Mezz FDR 2-Port InfiniBand Adapter (Mellanox uEFI driver) | 4 | 14.11.47 |
--------------------------------------------------------------------------------
| 16  | Intel X722 LOM (Etrack ID)                   | onboard | 8000115E       |
--------------------------------------------------------------------------------
| 17  | Intel X722 LOM (Combined Option ROM Image)   | onboard | 1.1892.0       |
--------------------------------------------------------------------------------
| 18  | Intel Optane DCPMM1                          | 1    | 01.02.00.5360     |
--------------------------------------------------------------------------------
| 19  | Intel Optane DCPMM12                         | 12   | 01.02.00.5360     |
--------------------------------------------------------------------------------
| 20  | Intel Optane DCPMM13                         | 13   | 01.02.00.5360     |
--------------------------------------------------------------------------------
| 21  | Intel Optane DCPMM24                         | 24   | 01.02.00.5360     |
================================================================================
```

Figure 12   OneCLI firmware scan results

Updating firmware using Lenovo XClarity Administrator

DCPMM firmware can be updated in LXCA as shown in Figure 13.

Figure 13   DCPMM firmware update In LXCA

Operating system support

The following operating systems support Intel DCPMMs.

▶ **Microsoft Windows Server**

Windows Server 2019 supports Intel DCPMM in both Memory Mode and App Direct mode. For details, refer to:

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

▶ **VMware vSphere / ESXi**

VMware vSphere supports Intel DCPMM as follows:

– App Direct Mode: with vSphere 6.7EP05 (ESXi670-201811001) or newer. This is fully supported to be deployed in production environments, without restrictions.

– Memory Mode: with vSphere 6.7EP13 (ESXi650-201903001). VMware will support Memory mode production deployment for limited use-cases. Such deployment requires explicit approval from VMware for support.

For details and more information, refer to:

https://vspherecentral.vmware.com/t/hardware-acceleration/persistent-memory-pme m/announcing-vmware-vsphere-support-for-intel-r-optane-tm-dc-persistent-memory- technology/

For information about Lenovo's specific certification and support for Intel DCPMM on VMware, refer to:

https://kb.vmware.com/s/article/68023

▶ **Red Hat Enterprise Linux (RHEL)**

RHEL 7.6 and RHEL 8.0 support Intel DCPMM in both Memory Mode and App Direct mode. For App Direct mode, the support is as follows:

– Block Mode is fully supported in RHEL 7.3 and later

– Device DAX is fully supported in RHEL 7.4 and later

– File System DAX for ext4 and XFS is "Technology Preview" in RHEL 7.6 and RHEL 8.0 (see RHEL 7.6 Release Notes for more details) and is targeted for full support in a future minor release of Red Hat Enterprise Linux 7.

For more information, refer to:

https://access.redhat.com/articles/3830541

https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/7/html/storage_administration_guide/ch-persistent-memory-nvdimms

► **SUSE Linux Enterprise Server (SLES)**

SLES 12 SP4 and SLES 15 supports Intel DCPMM in both Memory Mode and App Direct mode.

For more details and information on SLES support for Intel DCPMM with SAP HANA workloads, refer to:

https://www.suse.com/c/news/suse-partners-with-intel-and-sap-to-accelerate-it-transformation-with-persistent-memory-in-the-data-center/

Management in operating systems

In addition to Lenovo tools, users can manage Intel DCPMM in operating systems using the tools provided in the operating systems:

► "ipmctl"
► "ndctl" on page 20
► "Windows PowerShell commands" on page 20
► "VMware vSphere management" on page 21

ipmctl

This is an open source tool that can be used under Windows or Linux to configure and manage Intel DCPMM devices. The tool source code is available from:

https://github.com/intel/ipmctl

The tool supports the following functionality:

► Discover DCPMMs on the platform
► Provision the platform memory configuration
► View and update DCPMM firmware
► Configure data-at-rest security
► Monitor PMM health
► Track DCPMM performance
► Debug and troubleshoot DCPMMs

Examples of using ipmctl:

Show the DCPMM inventory and health status overview, Figure 14

```
ipmctl show -dimm
```

```
PS C:\Users\Administrator> ipmctl show -dimm

DimmID | Capacity  | HealthState | ActionRequired | LockState | FWVersion
=========================================================================
0x0001 | 502.5 GiB | Healthy     | 0              | Disabled  | 01.02.00.5355
0x0011 | 502.5 GiB | Healthy     | 0              | Disabled  | 01.02.00.5355
```

Figure 14   Output of the ipmctl show -dimm command

Show detailed DCPMM health information, Figure 15

```
ipmctl show -sensor
```



```
PS C:\Users\Administrator> ipmctl show -sensor

DimmID | Type                        | CurrentValue | CurrentState
==================================================================
0x0001 | Health                      | Healthy      | Normal
0x0001 | MediaTemperature            | 43C          | Normal
0x0001 | ControllerTemperature       | 45C          | Normal
0x0001 | PercentageRemaining         | 100%         | Normal
0x0001 | LatchedDirtyShutdownCount   | 32           | Normal
0x0001 | PowerOnTime                 | 2971015s     | Normal
0x0001 | UpTime                      | 1393s        | Normal
0x0001 | PowerCycles                 | 321          | Normal
0x0001 | FwErrorCount                | 8            | Normal
0x0001 | UnlatchedDirtyShutdownCount | 88           | Normal
0x0011 | Health                      | Healthy      | Normal
0x0011 | MediaTemperature            | 45C          | Normal
0x0011 | ControllerTemperature       | 45C          | Normal
0x0011 | PercentageRemaining         | 100%         | Normal
0x0011 | LatchedDirtyShutdownCount   | 6            | Normal
0x0011 | PowerOnTime                 | 2404897s     | Normal
0x0011 | UpTime                      | 1393s        | Normal
0x0011 | PowerCycles                 | 199          | Normal
0x0011 | FwErrorCount                | 8            | Normal
0x0011 | UnlatchedDirtyShutdownCount | 44           | Normal
```

Figure 15   Output of the ipmctl show -sensor command

For more information on using ipmctl, refer to:

► Lenovo documentation of the tool at:

https://datacentersupport.lenovo.com/us/en/products/servers/thinksystem/sr850/solutions/HT508252

► Lenovo video showing usage of the tool:

https://youtu.be/pzSsdcfL-vg
https://v.youku.com/v_show/id_XNDE3MTYxMDk5Ng

ndctl

Linux users can also use the ndctl tool to manage Intel DCPMM.

For more information, refer to the tool user guide

https://docs.pmem.io/ndctl-users-guide

Windows PowerShell commands

Windows Server 2019 offers native commands for managing Intel DCPMMs:

```
Get-PmemDisk
Get-PmemPhysicalDevice
Get-PmemUnusedRegion
New-PmemDisk
```

For details on these commands, and how they can be used to manage Intel DCPMM devices, refer to the following document:

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

You can also review the Lenovo Press paper, *Implementing Intel Optane DC Persistent Memory on Windows Server 2019*, available from:

https://lenovopress.com/lp1192-implementing-intel-optane-dcpmm-on-ws-2019

Lenovo offers a sample PowerShell script (pmemtool) that uses these native commands to manage DCPMM. The script open source is available from github:

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

VMware vSphere management

You can manage Intel DCPMM devices under VMware vSphere using the following:

► Virtual Persistent Memory (vPMem)

► Virtual Persistent Memory Disk (vPMemDisk)

For details, refer to VMware vSphere documentation:

https://docs.vmware.com/en/VMware-vSphere/6.7/com.vmware.vsphere.resmgmt.doc/GUID-EB72D358-9C2C-4FBD-81A9-A145E155CE31.html

Health management

Lenovo ThinkSystem servers monitor the health of DCPMMs and will send an alert to the administrator when user attention is needed.

The server monitors the available capacity of DCPMM storage media. When the available capacity approaches a user-settable threshold, or reaches zero, the system will send an alert. The alert will be forwarded to all XCC customer-visible logs and surfaced via industry standard alerting schemes supported by Lenovo XCC.

Additionally, the DCPMM media controller does internal wear-leveling and abstracts this information with SMART data reporting of the remaining spare capacity.

DCPMMs also has internal scrub engine and supporting ECC algorithm to recover correctable errors. DCPMMs also support similar Single Device Data Correction (SDDC) and Double Device Data Correction (DDDC) feature as DDR DIMM; the DCPMM media controller will handle the correctable error directly, so only uncorrectable errors will be triggered to interrupt or error pin and let SMI handler or BMC to handle.

Another RAS feature called *Address Range Scrub* (ARS), allows UEFI or the operating system to scrub the media to proactively catch errors.

ThinkSystem UEFI will always start ARS on boot under the following conditions:

► When the OS (for example, Linux or ESXi) first comes with Query ARS Status, the BIOS will abort the ARS behind the scenes and report partial results via Query ARS Status with Ended Prematurely extended status and the Overflow bit set.

► When the OS (such as Windows) first comes with Start ARS, the BIOS will abort the ARS behind the scenes and service the Start ARS DSM as normal.

Lenovo LXPM supports DCPMM diagnostics, which can do DCPMM-related tests and also provides the test result. For details, see the LXPM User Guide. From within LXPM, select **Diagnostics** → **Run Diagnostic**, then click **DCPMM test**.

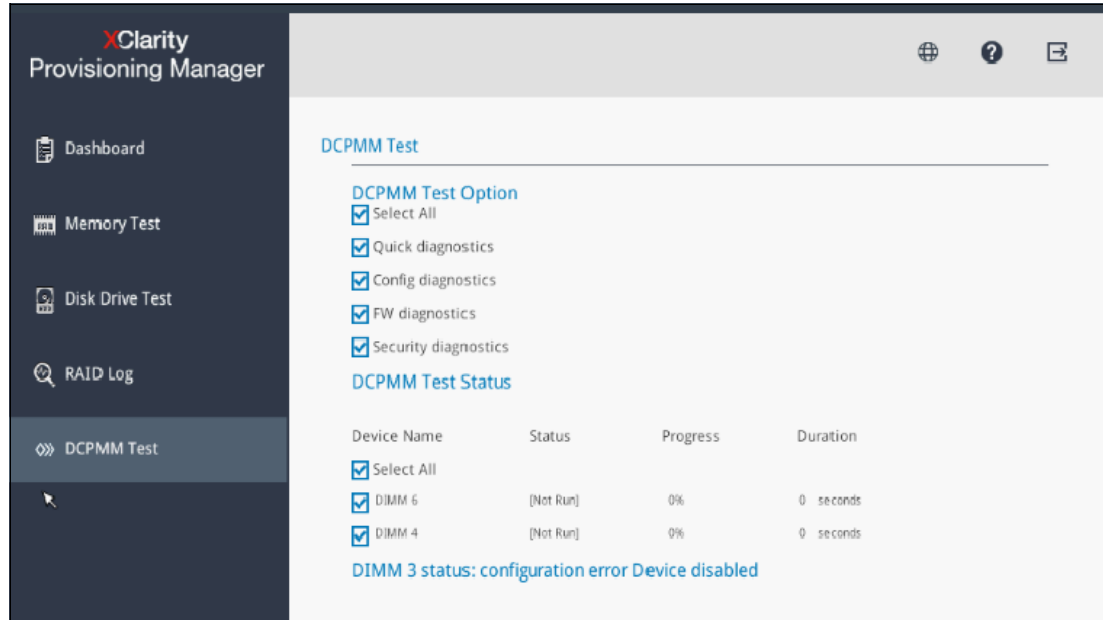Figure 16 shows the DCPMM diagnostics page in LXPM.

Figure 16   DCPMM diagnostic page in LXPM

Moving DCPMMs to a new system board

In instances when a system planar replacement is required, special consideration is necessary to ensure the persistent data contained in DCPMMs are not lost during migration:

► If DCPMMs are configured with interleaved App Direct Mode or Mixed Mode

  – All DCPMMs must install in the same position relative to the CPUs, memory controllers, and memory channels to avoid errors when moving DIMMs from one system to another

  – Lenovo ThinkSystem UEFI has a unique feature to support DCPMM migration for this case. Lenovo UEFI will verify and prompt user to change the DCPMM location if the new location is different from the previous one

► If DCPMMs are configured for Memory Mode or App Direct, not interleaved mode:

  – All DIMMs can be installed in any order in the new system by following the population rule.

Lenovo ThinkSystem UEFI has a unique DCPMM migration-events reporting feature. It will report three events for migration failure cases:

► Mistaken migration to a different platform type.

  If user migrated one group of DCPMMs from one type of system to a different system type. Event FQXSFMA0037G will be reported as shown in Figure 17:

Figure 17   DCPMM FQXSFMA0037G event

> ► Migrating DCPMMs with wrong locations.
>
>   If the user migrated one group of DCPMMs from one system to another, but some of them were populated in the wrong sequence, event FQXSFMA0033M will report how many DCPMM locations are incorrect, and then several events FQXSFMA0034M will report the wrong DCPMM location with recommendation for how to correct them, one by one. See Figure 18 for one example:

Figure 18   DCPMM FQXSFMA0033M and FQXSFMA0034M events

> ► Migration with missing DCPMMs.
>
>   If a user migrated one group of DCPMMs from one system to another system but some of them were missed, event FQXSFMA0035M will report how many DCPMMs are missing, and several events FQXSFMA0036M will report the missing DCPMMs one by one. See Figure 19 for an example:

Figure 19   DCPMM FQXSFMA0035M and FQXSFMA0036M events

Important note: Because the user does not know the original configuration of DCPMM, it is very important to ensure that the DCPMM location is maintained when the planar is changed

Security

The data in DCPMM is always encrypted with AES-256 encryption. The mode applied to the DCPMM determines how the encryption key is maintained.

► In Memory Mode: Encryption key for Volatile Region – provides equivalent security to DDR DIMMs. The encryption key is regenerated after each power cycle.

► In App Direct Mode: The user is able to set a 32-byte user-owned passphrase for user authentication to unlock the Persistent Region.

Lenovo ThinkSystem UEFI provides a unique DCPMM *Auto-unlock* feature. This is unique feature that is not available in the standard Intel implementation. The user can enable security for each DCPMM with a different passphrase, but the most common case is to enable DCPMM security at the platform (server) level—all DCPMMs in the server will share one passphrase.

If the user sets DCPMM security at the server level successfully, through either LXPM or OneCLI, then before booting to the OS (via either Legacy or UEFI), ThinkSystem UEFI will unlock the DCPMMs automatically. If auto-unlock fails, the detailed event info will be reported to the XCC event viewer. The user can also use the OneCLI command to get auto-unlock status.

Enabling security using LXPM

When a system boots, press F1 when prompted to boot to LXPM and select **UEFI Setup** → **System Settings** → **Intel Optane DCPMMs** → **Security**. Highlight **Press to Enable Security** and press Enter for one DCPMM. As shown in Figure 20, you can set a password for DCPMM.
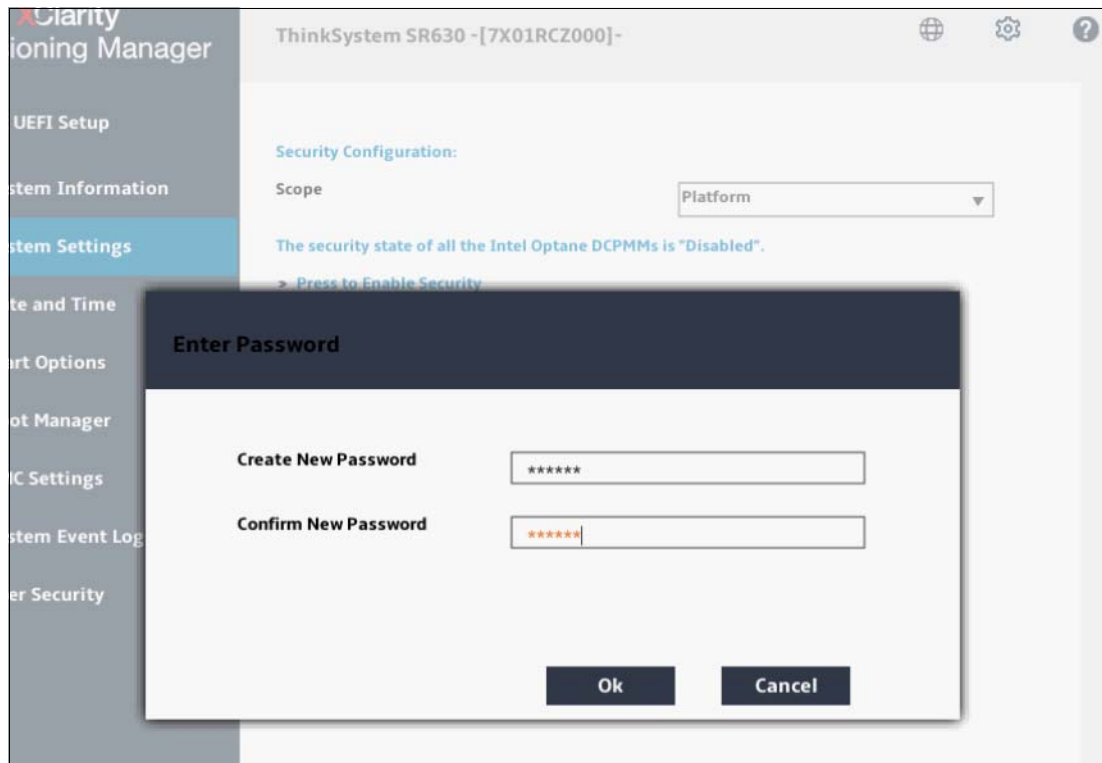

Figure 20   Enable DCPMM security in LXPM

Using the OneCLI command to get auto-unlock status

OneCLI can be used to get auto-unlock status. The command is as follows:

```
./OneCli config show IntelOptaneDCPMM --bmc USERID:password@bmc_ip
```

Sample output of the command is shown below:

```
IntelOptaneDCPMM.DcpmmSecurityState.1=Unlocked
IntelOptaneDCPMM.DcpmmSecurityState.2=Unlocked
IntelOptaneDCPMM.DcpmmAutoUnlockState.1=Success
IntelOptaneDCPMM.DcpmmAutoUnlockState.2=Success
```

Note: If a user set a passphrase, but lost it, please contact Lenovo for assistance.

UEFI Event IDs and Messages

Table 2 lists the Event IDs and messages relevant to DCPMMs.

For more detailed information and user actions about these Event IDs and messages, see the Messages Reference for your server in the Lenovo ThinkSystem Information Center:

https://thinksystem.lenovofiles.com/help/index.jsp

Table 2   UEFI Error / Warning / Information Event IDs and Messages

Event ID	Message String	Severity
FQXSFMA0030K	Intel Optane DCPMM DIMM [arg1] Percentage Remaining is less than [arg2]% and still functioning.	Warning
FQXSFMA0031K	Intel Optane DCPMM DIMM [arg1] has reached 1% remaining spares block and still functioning.	Warning
FQXSFMA0032M	Intel Optane DCPMM DIMM [arg1] has no remaining spares block.	Error
FQXSFMA0033M	Intel Optane DCPMM persistent memory interleave set has [arg1] DCPMMs (DIMM [arg2]), [arg3] DIMMs' location is not correct.	Error
FQXSFMA0034M	DIMM [arg1] (UID: [arg2]) of Intel Optane DCPMM persistent memory interleave set should be moved to DIMM slot [arg3] in sequence.	Error
FQXSFMA0035M	Intel Optane DCPMM interleave set should have [arg1] DCPMMs, but [arg2] DCPMMs are missing.	Error
FQXSFMA0036M	DIMM [arg1] (UID: [arg2]) of Intel Optane DCPMM persistent memory interleave set is missing.	Error
FQXSFMA0037G	Intel Optane DCPMM interleave set (DIMM [arg1]) is migrated from another system (Platform ID: [arg2]), these migrated DCPMMs are not supported nor warranted in this system.	Error
FQXSFMA0038K	All onboard Intel Optane DCPMMs could not be auto-unlocked because of no passphrase.	Warning
FQXSFMA0039K	One or more onboard Intel Optane DCPMMs could not be auto-unlocked because of invalid passphrase.	Warning
FQXSFMA0040K	Invalid Intel Optane DCPMM configuration detected. Please verify DCPMM configuration is valid.	Error
FQXSFMA0041K	Near Memory/Far Memory ratio (1:[arg1].[arg2]) for Intel Optane DCPMM configuration is not in recommended range (1:4 - 1:16).	Error
FQXSFMA0042K	Intel Optane DCPMM is not supported by processor of this system.	Error

Further reading

For more information please consult these resources:

► Persistent Intel Optane DC Memory Product Guide

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

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