Intel Optane Persistent Memory 100 Series
Product Guide (withdrawn product)

Intel Optane DC Persistent Memory represents a new class of memory and storage technology explicitly architected for data center usage. It offers three main benefits:

- Significantly lower latency than fetching data from system storage
- High capacities
- Affordable cost

Using Lenovo ThinkSystem servers running applications that are tuned for Intel Optane DC Persistent Memory will result in lower data latency compared to solid-state drive technology. When data is stored closer to the processor on nonvolatile media, applications can see significant overall improvement in performance.

An Intel Optane DC Persistent Memory Module (DCPMM) is shown in the following figure.

Figure 1. Intel Optane DC Persistent Memory Module (DCPMM)

Did you know?

Intel Optane DC Persistent Memory modules (DCPMMs) have the form factor of a DDR4 DIMM, but the persistence and capacity of data storage of a solid-state drive. This means the DCPMMs have performance characteristics similar to that of TruDDR4 DIMMs, the storage capacity of an SSD, and the ability to stay active after a power cycle or reboot of the server. These features open up a new way of performing data I/O to application developers and new levels of server performance to customers.

Part numbers

The following table lists the ordering information for the persistent memory options.

Withdrawn: The persistent memory part numbers described in this product guide are now withdrawn from marketing.

Table 1. Ordering information

Part number	Feature code	Description
For ThinkSystem servers except ThinkSystem SD650		
4ZC7A15110	B4LV	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory
4ZC7A15111	B4LW	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory
4ZC7A15112	B4LX	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory
For ThinkSystem SD650		
CTO only*	B691	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory for SD650
CTO only*	B692	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory for SD650
CTO only*	B693	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory for SD650

* Configure-to-order only, not available as a field upgrade. Planned for late 2Q/2019

DCPMM modes

Intel Optane DC Persistent Memory operates in one of three modes:

- **Memory Mode**

  In this mode, the DCPMMs act as large capacity DDR4 memory modules. In such a configuration, the memory that the operating system recognizes is the DCPMMs; the installed TruDDR4 DIMMs are hidden from the operating system and act as a caching layer for the DCPMMs. In this mode, the persistence feature of the DCPMMs is disabled. This mode does not require the application to be DCPMM-aware.

- **App Direct Mode**

  In this mode, the DCPMMs provide all persistence features to the operating system and applications that support them. The operating system presents both TruDDR4 DIMMs and DCPMMs to the applications, as system memory and persistent storage respectively.

  Depending on the configuration in UEFI and the operating system, the DCPMMs appear as one of two types of namespaces:

  - Direct access (DAX): byte-addressable storage accessible via an API. The applications must be DCPMM-aware and use the published APIs to implement the DCPMM features.
  - Block storage: the persistent memory is presented to applications is seen as a block storage device, similar to an SSD. The operating system needs to be DCPMM-aware, however the applications do not.

  Applications with planned support include:

  - SAP HANA
  - Aerospike Enterprise Edition
  - Gigaspaces
  - Apache Cassandra
  - Apache Spark SQL with OAP
  - Apache HBase Bucket Cache
  - Apache Hadoop HDFS Cache

- **Mixed Memory Mode**

  Mixed Memory Mode is a combination of Memory Mode and App Direct Mode, where a portion of the capacity of the DCPMMs is used for the Memory Mode operations, and the remaining capacity of the DCPMMs is used for the App Direct Mode operations. In this mode, all installed TruDDR4 DIMMs are hidden from the operating system and act as a caching layer for portion of the DCPMMs in Memory Mode.

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

- Interleaved, where all DCPMMs are seen as one single monolithic space. This is similar in concept to RAID-0 in storage.

- Non-interleaved, where each DCPMM is seen as a separate space. This is similar in concept to JBOD in storage.

For configure-to-order (CTO) configurations, the feature codes listed in the following table specify the DCPMM mode you wish to enable.

Table 2. DCPMM operating modes

Feature code	Description
B528	DCPMM Memory mode
B529	DCPMM App Direct mode
B52A	DCPMM Mixed Memory mode
B52B	DCPMM Interleaved mode
B52C	DCPMM Non-interleaved mode

The following figure shows a Lenovo TruDDR4 DIMM and an Intel Optane DC Persistent Memory Module.

Figure 2. Intel Optane DC Persistent Memory Module (top) and Lenovo TruDDR4 DIMM (bottom)

Benefits

Intel Optane DC Persistent Memory provides benefits in the following application types:

- Larger memory footprint: For applications with performance characteristics that place greater emphasis on memory capacity over memory bandwidth or memory latency, the use of DCPMMs can mean a significant increase in overall system performance compared to the use of TruDDR4 DIMMs.
    - Cloud and Infrastructure-as-a-service (IaaS) applications
    - More virtual machines and cloud containers per server
    - Larger memory allocation to each VM

- In-memory databases: With DCPMMs, database applications have store much larger databases in persistent memory rather than on disk, and database performance will be improved significantly. For existing applications that use system RAM for in-memory databases, the use of persistent memory will mean no delays at boot time having to copy the databases from disk into memory.

- Storage caching layers: TruDDR4 DIMMs can be used for the fastest memory access - best throughput and lowest latency, and DCPMMs can be used for the caching layer that offers memory-like performance with the persistence of SSD storage.

- NFV infrastructure: Network Function Virtualization (NFV) can make use of increased memory capacity and performance with the addition of DCPMMs.
    - High capacity non-volatile cache for enterprise and cloud storage
    - High capacity local cache for network storage App Direct direct-attach storage

Specifications

Intel Optane DCPMMs have the following specifications:

- DCPMMs are installed in standard memory slots in supported servers
- 2666 MHz memory bus speed. Any 2933 MHz TruDDR4 DIMMs installed will also operate at 2666 MHz.
- Optional data encryption using AES 256-bit encryption
- Optional data security in App Direct mode, including secure erase functionality
- Firmware updates through XClarity Administrator and other Lenovo support tools

DCPMMs offer the following memory protection technologies:

- ECC
- SDDC
- DDDC
- Patrol scrubbing
- Demand scrubbing

Implementation requirements

The following are the requirements when selecting the number of DIMMs and DCPMMs:

- DCPMMs require second generation Intel Xeon Scalable Family processors. First generation Xeon Scalable processors are not supported.
- All Platinum processors, all Gold processors and the Silver 4215 processor support DCPMM.
- All installed DCPMMs must be the same size. Mixing DCPMMs of different capacities is not supported
- All installed DIMMs must be the same size and structure (ie same part number). Mixing different DIMMs is not supported
- The use of 1Rx8 DIMMs with DCPMMs is not supported. See the Memory DIMM support section for specifics.
- Maximum 6 DCPMMs per processor (install 1 in each memory channel)
- Minimum 2 TruDDR4 DIMMs per processor (1 per memory controller)
- For Memory Mode, minimum 2 DCPMMs per processor (install 1 per memory controller)
- For App Direct Mode, minimum 1 DCPMM installed in the server (any processor)
- When either Memory Mode or Mixed Mode is used, the ratio of memory to DCPMMs must be between 1:16 and 1:2, and the recommended ratio is 1:4 for the best performance. For example, 6x 16GB DIMMs + 2x 256GB DCPMMs is a ratio of 1:5.33. In Mixed Mode, the ratio is between memory and only the volatile portion of the DCPMMs. This ratio requirement does not apply to App Direct mode.
- For each memory channel with both a DCPMM and a TruDDR4 DIMM installed, the DCPMM is installed in channel slot 1 (closest) and the DIMM is installed in channel slot 0
- To maximize performance, balance all memory channels
- In configurations with DCPMMs installed, memory mirroring is supported, with two restrictions:
    - Mirroring is only enabled on the DRAM DIMMs installed in the server; The DCPMMs themselves do not support mirroring.
    - Only App Direct mode is supported. Memory mirroring cannot be enabled when DCPMMs are in Memory Mode or Mixed Mode.
- Memory sparing is not supported with DCPMMs installed

The following figure shows DCPMMs and TruDDR4 DIMMs installed in the system board of a ThinkSystem SR950. In this full configuration, there is one DCPMM and one TruDDR4 DIMM installed in each memory channel (6 DCPMMs and 6 DIMMs per processor).
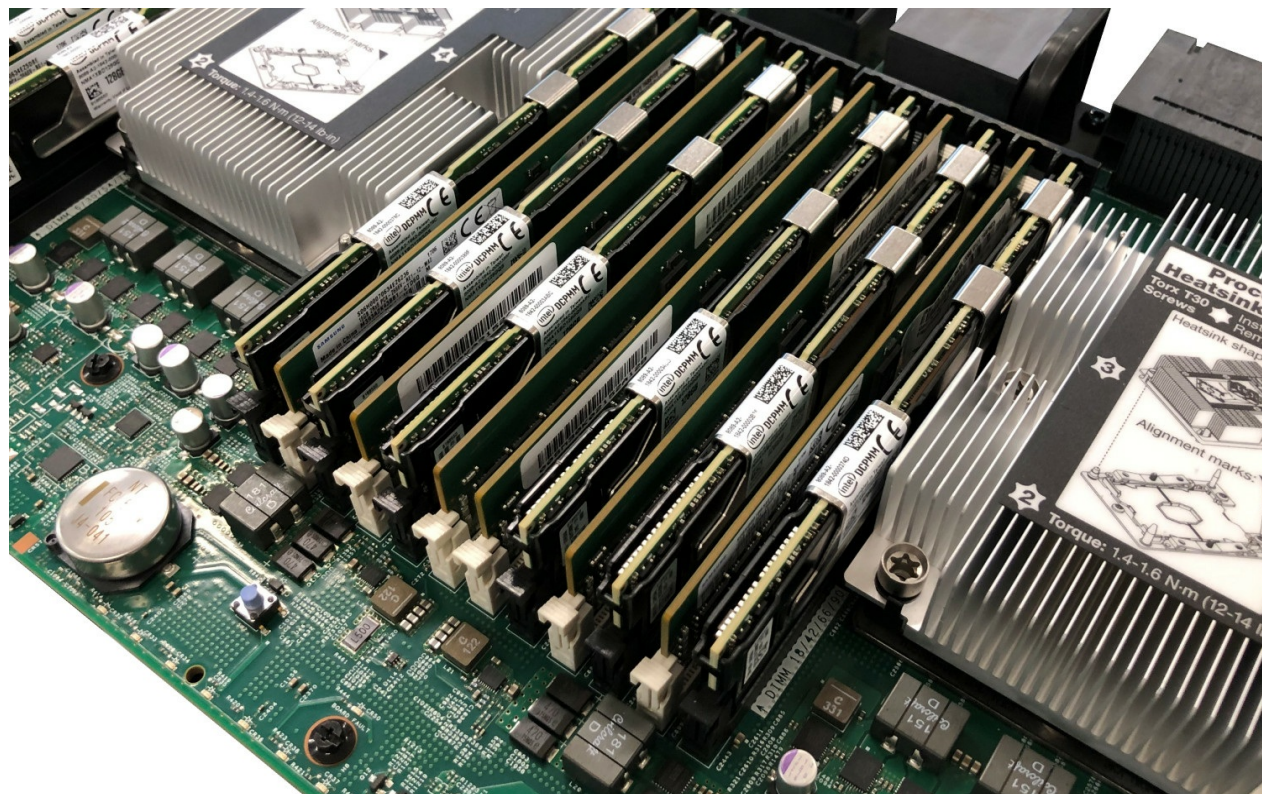
Figure 3. Intel Optane DCPMMs installed in a ThinkSystem SR950 system board

App Direct Mode requirements

The following table lists the supported combinations in App Direct mode.

Table 3. App Direct Mode requirements

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
			16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
96 GB	128 GB	224 GB	6						1		
96 GB	128 GB	224 GB		6					1		
192 GB	128 GB	320 GB			6				1		
384 GB	128 GB	512 GB				6			1		
384 GB	128 GB	512 GB					6		1		
768 GB	128 GB	896 GB						6	1		
96 GB	256 GB	352 GB	6							1	
96 GB	256 GB	352 GB		6						1	
192 GB	256 GB	448 GB			6					1	
384 GB	256 GB	640 GB				6				1	
384 GB	256 GB	640 GB					6			1	

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
			16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
768 GB	256 GB	1 TB						6		1	
96 GB	512 GB	608 GB	6								1
96 GB	512 GB	608 GB		6							1
192 GB	512 GB	704 GB			6						1
384 GB	512 GB	896 GB				6					1
384 GB	512 GB	896 GB					6				1
768 GB	512 GB	1.25 TB						6			1
64 GB	256 GB	320 GB	4						2		
64 GB	256 GB	320 GB		4					2		
128 GB	256 GB	384 GB			4				2		
256 GB	256 GB	512 GB				4			2		
256 GB	256 GB	512 GB					4		2		
512 GB	256 GB	768 GB						4	2		
64 GB	512 GB	576 GB	4							2	
64 GB	512 GB	576 GB		4						2	
128 GB	512 GB	640 GB			4					2	
256 GB	512 GB	768 GB				4				2	
256 GB	512 GB	768 GB					4			2	
512 GB	512 GB	1 TB						4		2	
64 GB	1 TB	1.063 TB	4								2
64 GB	1 TB	1.063 TB		4							2
128 GB	1 TB	1.125 TB			4						2
256 GB	1 TB	1.25 TB				4					2
256 GB	1 TB	1.25 TB					4				2
512 GB	1 TB	1.5 TB						4			2
96 GB	256 GB	352 GB	6						2		
96 GB	256 GB	352 GB		6					2		
192 GB	256 GB	448 GB			6				2		
384 GB	256 GB	640 GB				6			2		
384 GB	256 GB	640 GB					6		2		
768 GB	256 GB	1 TB						6	2		
96 GB	512 GB	608 GB	6							2	
96 GB	512 GB	608 GB		6						2	
192 GB	512 GB	704 GB			6					2	
384 GB	512 GB	896 GB				6				2	
384 GB	512 GB	896 GB					6			2	
768 GB	512 GB	1.25 TB						6		2	
96 GB	1 TB	1.094 TB	6								2
96 GB	1 TB	1.094 TB		6							2
192 GB	1 TB	1.188 TB			6						2
384 GB	1 TB	1.375 TB				6					2
384 GB	1 TB	1.375 TB					6				2
768 GB	1 TB	1.75 TB						6			2

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
			16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
128 GB	256 GB	384 GB	8						2		
128 GB	256 GB	384 GB		8					2		
256 GB	256 GB	512 GB			8				2		
512 GB	256 GB	768 GB				8			2		
512 GB	256 GB	768 GB					8		2		
1 TB	256 GB	1.25 TB						8	2		
128 GB	512 GB	640 GB	8							2	
128 GB	512 GB	640 GB		8						2	
256 GB	512 GB	768 GB			8					2	
512 GB	512 GB	1 TB				8				2	
512 GB	512 GB	1 TB					8			2	
1 TB	512 GB	1.5 TB						8		2	
128 GB	1 TB	1.125 TB	8								2
128 GB	1 TB	1.125 TB		8							2
256 GB	1 TB	1.25 TB			8						2
512 GB	1 TB	1.5 TB				8					2
512 GB	1 TB	1.5 TB					8				2
1 TB	1 TB	2 TB						8			2
96 GB	512 GB	608 GB	6						4		
96 GB	512 GB	608 GB		6					4		
192 GB	512 GB	704 GB			6				4		
384 GB	512 GB	896 GB				6			4		
384 GB	512 GB	896 GB					6		4		
768 GB	512 GB	1.25 TB						6	4		
96 GB	1 TB	1.094 TB	6							4	
96 GB	1 TB	1.094 TB		6						4	
192 GB	1 TB	1.188 TB			6					4	
384 GB	1 TB	1.375 TB				6				4	
384 GB	1 TB	1.375 TB					6			4	
768 GB	1 TB	1.75 TB						6		4	
96 GB	2 TB	2.094 TB	6								4
96 GB	2 TB	2.094 TB		6							4
192 GB	2 TB	2.188 TB			6						4
384 GB	2 TB	2.375 TB				6					4
384 GB	2 TB	2.375 TB					6				4
768 GB	2 TB	2.75 TB						6			4
96 GB	768 GB	864 GB	6						6		
96 GB	768 GB	864 GB		6					6		
192 GB	768 GB	960 GB			6				6		
384 GB	768 GB	1.125 TB				6			6		
384 GB	768 GB	1.125 TB					6		6		
768 GB	768 GB	1.5 TB						6	6		
96 GB	1.5 TB	1.594 TB	6							6	

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
			16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
96 GB	1.5 TB	1.594 TB		6						6	
192 GB	1.5 TB	1.688 TB			6					6	
384 GB	1.5 TB	1.875 TB				6				6	
384 GB	1.5 TB	1.875 TB					6			6	
768 GB	1.5 TB	2.25 TB						6		6	
96 GB	3 TB	3.094 TB	6								6
96 GB	3 TB	3.094 TB		6							6
192 GB	3 TB	3.188 TB			6						6
384 GB	3 TB	3.375 TB				6					6
384 GB	3 TB	3.375 TB					6				6
768 GB	3 TB	3.75 TB						6			6

* In App Direct Mode, the available memory = system memory installed + persistent memory installed. The actual user capacity of PMem modules is less than the stated amount. For example, a 128GB PMem module has 126.7GB usable storage.

Memory Mode requirements

In Memory Mode, the DCPMMs are seen by the operating system as system memory. The memory DIMMs are hidden from the operating system and are used as a high-speed cache for the DCPMMs.

Key to performance is the ratio of total DIMMs to total DCPMMs. The recommended range of DIMMs:DCPMMs is between 1:2 and 1:16:

- 1:16 means 1GB of DIMMs (used for cache) for every 16GB of DCPMM capacity (used as system memory). A larger number than 16 means potentially worse performance since the chances of a cache hit in memory will be lower.
- 1:2 means 1GB of DIMMs for every 2GB of DCPMM capacity. 1:2 maximizes the performance of the memory subsystem while still using persistent memory for increased capacity. Note: Ratios of between 1:2 and 1:4 require the latest firmware.

DCPMMs are only supported in quantities of 1, 2, 4 and 6 per processor, and only certain quantities of memory DIMMs are supported alongside the DCPMMs, as listed in the following table.

The specific memory part numbers that are supported with DCPMMs is listed in the Memory DIMM support section.

Table 4. Memory Mode requirements

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Ratio (RDIMM: Pmem)†	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
				16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
64 GB	256 GB	256 GB	1:4	4						2		
64 GB	256 GB	256 GB	1:4		4					2		
128 GB	256 GB	256 GB	1:2			4				2		
64 GB	512 GB	512 GB	1:8	4							2	
64 GB	512 GB	512 GB	1:8		4						2	
128 GB	512 GB	512 GB	1:4			4					2	

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Ratio (RDIMM: Pmem)†	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
				16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
256 GB	512 GB	512 GB	1:2				4				2	
256 GB	512 GB	512 GB	1:2					4			2	
64 GB	1 TB	1 TB	1:16	4								2
64 GB	1 TB	1 TB	1:16		4							2
128 GB	1 TB	1 TB	1:8			4						2
256 GB	1 TB	1 TB	1:4				4					2
256 GB	1 TB	1 TB	1:4					4				2
512 GB	1 TB	1 TB	1:2						4			2
96 GB	256 GB	256 GB	1:2.67	6						2		
96 GB	256 GB	256 GB	1:2.67		6					2		
96 GB	512 GB	512 GB	1:5.33	6							2	
96 GB	512 GB	512 GB	1:5.33		6						2	
192 GB	512 GB	512 GB	1:2.67			6					2	
96 GB	1 TB	1 TB	1:10.67	6								2
96 GB	1 TB	1 TB	1:10.67		6							2
192 GB	1 TB	1 TB	1:5.33			6						2
384 GB	1 TB	1 TB	1:2.67				6					2
384 GB	1 TB	1 TB	1:2.67					6				2
96 GB	512 GB	512 GB	1:5.33	6						4		
96 GB	512 GB	512 GB	1:5.33		6					4		
192 GB	512 GB	512 GB	1:2.67			6				4		
96 GB	1 TB	1 TB	1:10.67	6							4	
96 GB	1 TB	1 TB	1:10.67		6						4	
192 GB	1 TB	1 TB	1:5.33			6					4	
384 GB	1 TB	1 TB	1:2.67				6				4	
384 GB	1 TB	1 TB	1:2.67					6			4	
192 GB	2 TB	2 TB	1:10.67			6						4
384 GB	2 TB	2 TB	1:5.33				6					4
384 GB	2 TB	2 TB	1:5.33					6				4
768 GB	2 TB	2 TB	1:2.67						6			4
96 GB	768 GB	768 GB	1:8	6						6		
96 GB	768 GB	768 GB	1:8		6					6		
192 GB	768 GB	768 GB	1:4			6				6		
384 GB	768 GB	768 GB	1:2				6			6		
384 GB	768 GB	768 GB	1:2					6		6		
96 GB	1.5 TB	1.5 TB	1:16	6							6	
96 GB	1.5 TB	1.5 TB	1:16		6						6	
192 GB	1.5 TB	1.5 TB	1:8			6					6	
384 GB	1.5 TB	1.5 TB	1:4				6				6	
384 GB	1.5 TB	1.5 TB	1:4					6			6	
768 GB	1.5 TB	1.5 TB	1:2						6		6	
192 GB	3 TB	3 TB	1:16			6						6
384 GB	3 TB	3 TB	1:8				6					6

Total RDIMMs per CPU	Total PMem per CPU	Total Available Memory per CPU*	Ratio (RDIMM: Pmem)†	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
				16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
384 GB	3 TB	3 TB	1:8					6				6
768 GB	3 TB	3 TB	1:4						6			6

* In Memory Mode, the available memory = persistent memory installed. The actual user capacity of PMem modules is less than the stated amount. For example, a 128GB PMem module has 126.7GB usable storage.

† Ratio of system memory to persistent memory, RDIMM:PMem; Memory Mode only supports DIMM:Pmem ratios of between 1:2 and 1:16. Ratios between 1:2 and 1:4 require the latest firmware.

Mixed Mode requirements

Mixed Memory Mode is a combination of Memory Mode and App Direct Mode, where a portion of the capacity of the DCPMMs is used for the Memory Mode operations, and the remaining capacity of the DCPMMs is used for the App Direct Mode operations.

In Mixed Mode, all installed TruDDR4 DIMMs are hidden from the operating system and act as a caching layer for portion of the DCPMMs in Memory Mode. Like Memory Mode, the ratio of total of the memory DIMMs to the total of the volatile (memory) portion of DCPMMs should be between 1:4 and 1:16.

When you enable Mixed Memory Mode in UEFI or you specify Mixed Memory Mode when building a CTO (configure-to-order) configuration (feature B52A), you will also be asked to specify the percentage of the DCPMM total capacity will be allocated to Memory Mode. The remaining DCPMM capacity will be allocated to App Direct Mode.

The following tables show the allowed percentage for each DCPMM part number and what the effective amount of App Direct persistent memory will be available to applications. Only a set number of percentages are available to choose from and the amount of App Direct persistent memory that is allocated will be in increments of 32 GB multiplied by the number of DCPMMs installed.

Table 5. Available ratios available for Mixed Mode - 128 GB DCPMM

Volatile memory percentage requested (selected in UEFI or quantity of feature code B52D selected in CTO):	Resulting Persistent percentage calculated (quantity of feature code B52E in CTO)	DCPMM capacity reserved for App Direct Mode	DCPMM capacity reserved for Memory Mode
24%	76%	96 GB	32 GB
49%	51%	64 GB	64 GB
75%	25%	32 GB	96 GB

Table 6. Available ratios available for Mixed Mode - 256 GB DCPMM

Volatile memory percentage requested (selected in UEFI or quantity of feature code B52D selected in CTO):	Resulting Persistent percentage calculated (quantity of feature code B52E in CTO)	DCPMM capacity reserved for App Direct Mode	DCPMM capacity reserved for Memory Mode
11%	89%	224 GB	32 GB
24%	76%	192 GB	64 GB
37%	63%	160 GB	96 GB
49%	51%	128 GB	128 GB
62%	38%	96 GB	160 GB
75%	25%	64 GB	192 GB
87%	13%	32 GB	224 GB

Table 7. Available ratios available for Mixed Mode - 512 GB DCPMM

Volatile memory percentage requested (selected in UEFI or quantity of feature code B52D selected in CTO):	Resulting Persistent percentage calculated (quantity of feature code B52E in CTO)	DCPMM capacity reserved for App Direct Mode	DCPMM capacity reserved for Memory Mode
4%	96%	480 GB	32 GB
11%	89%	448 GB	64 GB
17%	83%	416 GB	96 GB
24%	76%	384 GB	128 GB
30%	70%	352 GB	160 GB
36%	64%	320 GB	192 GB
43%	57%	288 GB	224 GB
49%	51%	256 GB	256 GB
55%	45%	224 GB	288 GB
62%	38%	192 GB	320 GB
68%	32%	160 GB	352 GB
75%	25%	128 GB	384 GB
81%	19%	96 GB	416 GB
87%	13%	64 GB	448 GB
94%	6%	32 GB	480 GB

The following table shows the supported combinations of DCPMMs and DIMMs. The key requirement for support is ensuring that the ratio of the total memory DIMMs capacity to the total of the volatile (memory) portion of DCPMMs should be between 1:2 and 1:16. Ratios between 1:2 and 1:4 require the latest firmware.

Table 8. Mixed Mode requirements

Total RDIMMs per CPU	Total PMem per CPU	Ratio (RDIMM: Pmem)†	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
			16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
64 GB	512 GB	1:8	4							2	
64 GB	512 GB	1:8		4						2	
128 GB	512 GB	1:4			4					2	
64 GB	1 TB	1:16	4								2
64 GB	1 TB	1:16		4							2
128 GB	1 TB	1:8			4						2
256 GB	1 TB	1:4				4					2
256 GB	1 TB	1:4					4				2
96 GB	256 GB	1:2.67	6						2		
96 GB	256 GB	1:2.67		6					2		
96 GB	512 GB	1:5.33	6							2	
96 GB	512 GB	1:5.33		6						2	
192 GB	512 GB	1:2.67			6					2	
96 GB	1 TB	1:10.67	6								2
96 GB	1 TB	1:10.67		6							2
192 GB	1 TB	1:5.33			6						2
384 GB	1 TB	1:2.67				6					2
384 GB	1 TB	1:2.67					6				2
96 GB	512 GB	1:5.33	6						4		
96 GB	512 GB	1:5.33		6					4		
192 GB	512 GB	1:2.67			6				4		
96 GB	1 TB	1:10.67	6							4	
96 GB	1 TB	1:10.67		6						4	
192 GB	1 TB	1:5.33			6					4	
384 GB	1 TB	1:2.67				6				4	
384 GB	1 TB	1:2.67					6			4	
96 GB	2 TB	1:21.33	6								4
96 GB	2 TB	1:21.33		6							4
192 GB	2 TB	1:10.67			6						4
384 GB	2 TB	1:5.33				6					4
384 GB	2 TB	1:5.33					6				4
768 GB	2 TB	1:2.67						6			4
96 GB	768 GB	1:8	6						6		
96 GB	768 GB	1:8		6					6		
192 GB	768 GB	1:4			6				6		
96 GB	1.5 TB	1:16	6							6	
96 GB	1.5 TB	1:16		6						6	
192 GB	1.5 TB	1:8			6					6	
384 GB	1.5 TB	1:4				6				6	
384 GB	1.5 TB	1:4					6			6	
96 GB	3 TB	1:32	6								6

Total RDIMMs per CPU	Total PMem per CPU	Ratio (RDIMM: Pmem)†	Quantity of memory RDIMMs (per CPU)						Quantity of PMem modules (per CPU)		
			16GB 1Rx4	16GB 2Rx8	32GB	64GB	64GB 3DS RDIMM	128GB 3DS RDIMM	128GB PMem	256GB PMem	512GB PMem
96 GB	3 TB	1:32		6							6
192 GB	3 TB	1:16			6						6
384 GB	3 TB	1:8				6					6
384 GB	3 TB	1:8					6				6
768 GB	3 TB	1:4						6			6

† Ratio of system memory to persistent memory, RDIMM:PMem; Memory Mode only supports DIMM:Pmem ratios of between 1:2 and 1:16. Ratios between 1:2 and 1:4 require the latest firmware.

Memory DIMM support

The following table lists which TruDDR4 DIMMs can be installed with DCPMMs. 2933 MHz DIMMs will operate at 2666 MHz with installed with DCPMMs.

Notes:

- RDIMMs, LRDIMMs and 3DS RDIMMs cannot be mixed.
- Not all servers support all memory options. See the Lenovo ThinkSystem Memory Summary for details:
  https://lenovopress.com/lp1021-lenovo-thinksystem-memory-summary

Table 9. Memory ordering information

Part number	Feature code	Description	Supports DCPMMs
2933 MHz RDIMMs (operate at 2666 MHz when installed with DCPMMs)			
4ZC7A08706	B4H1	ThinkSystem 8GB TruDDR4 2933MHz (1Rx8 1.2V) RDIMM	No
4ZC7A08707	B4LY	ThinkSystem 16GB TruDDR4 2933MHz (1Rx4 1.2V) RDIMM	Yes
4ZC7A08708	B4H2	ThinkSystem 16GB TruDDR4 2933MHz (2Rx8 1.2V) RDIMM	Yes
4ZC7A08709	B4H3	ThinkSystem 32GB TruDDR4 2933MHz (2Rx4 1.2V) RDIMM	Yes
4ZC7A08710	B4H4	ThinkSystem 64GB TruDDR4 2933MHz (2Rx4 1.2V) RDIMM	Yes
2933 MHz 3DS RDIMMs (operate at 2666 MHz when installed with DCPMMs)			
4ZC7A15113	B587	ThinkSystem 128GB TruDDR4 2933MHz (4Rx4 1.2V) 3DS RDIMM	Yes
4ZC7A08727	B4Y3	ThinkSystem 256GB TruDDR4 2933MHz (8Rx4 1.2V) 3DS RDIMM	Yes
2666 MHz RDIMMs			
7X77A01301	AUU1	ThinkSystem 8GB TruDDR4 2666 MHz (1Rx8 1.2V) RDIMM	No
CTO only	B21T	ThinkSystem 8GB TruDDR4 2666 MHz (2Rx8 1.2V) RDIMM	Yes
7X77A01302	AUNB	ThinkSystem 16GB TruDDR4 2666 MHz (1Rx4 1.2V) RDIMM	Yes
7X77A01303	AUNC	ThinkSystem 16GB TruDDR4 2666 MHz (2Rx8 1.2V) RDIMM	Yes
7X77A01304	AUND	ThinkSystem 32GB TruDDR4 2666 MHz (2Rx4 1.2V) RDIMM	Yes
2666 MHz LRDIMMs			
7X77A01305	AUNE	ThinkSystem 64GB TruDDR4 2666 MHz (4Rx4 1.2V) LRDIMM	Yes
2666 MHz 3DS RDIMMs			

Part number	Feature code	Description	Supports DCPMMs
4ZC7A08716	AUW5	ThinkSystem 64GB TruDDR4 2666MHz (4Rx4, 1.2V) 3DS RDIMM	Yes
7X77A01307	AUNF	ThinkSystem 128GB TruDDR4 2666 MHz (8Rx4 1.2V) 3DS RDIMM	Yes
2666 MHz UDIMMs			
4ZC7A08696	B35J	ThinkSystem 8GB TruDDR4 2666MHz (1Rx8, 1.2V) UDIMM	No
4ZC7A08699	B35K	ThinkSystem 16GB TruDDR4 2666MHz (2Rx8, 1.2V) UDIMM	No
4ZC7A08700	B35L	ThinkSystem 4GB TruDDR4 2666MHz (1Rx16, 1.2V) Non-ECC UDIMM	No
4ZC7A08701	B35M	ThinkSystem 8GB TruDDR4 2666MHz (1Rx8, 1.2V) Non-ECC UDIMM	No
4ZC7A08702	B35N	ThinkSystem 16GB TruDDR4 2666MHz (2Rx8, 1.2V) Non-ECC UDIMM	No

Processor support

Intel Optane DC Persistent Memory is supported by these processors:

- All second-generation Xeon Platinum (8200 series) processors
- All Second-generation Xeon Gold (6200 and 5200 series) processors
- The following second-generation Xeon Silver (4200 series) processor:
    - Intel Xeon Silver 4215 8C 85W 2.5GHz Processor
    - Intel Xeon Silver 4215R 8C 130W 3.2GHz Processor

Note: Some servers only support a subset of the above processors with DCPMMs due to thermal limitations. Consult the relevant server product guide for specifics.

Second-generation Xeon Scalable processors are limited to the amount of memory they can address, and this memory maximum also includes DCPMMs in the calculation:

- Processors with an L suffix (eg 8280L): 4.5 TB maximum per processor
- Processors with an M suffix (eg 8280M): 2 TB maximum per processor
- All other processors: 1 TB per processor

For example:

- A configuration using 12x 64GB DIMMs per processor is a total of 768 GB, which means that neither an M nor an L processor is required
- A configuration using 12x 256GB DIMMs per processor is a total of 3 TB, which means that an L processor is required
- A configuration using 6x 32GB DIMMs + 6x 256GB DCPMMs is a total of 1.69 TB which means an M processor is required (an L processor may also be used)
- A configuration using 6x 64GB DIMMs + 6x 512GB DCPMMs is a total of 3.375 TB which means an L processor is required
- A configuration using 6x 256GB DIMMs + 6x 512GB DCPMMs is a total of 4.5 TB which means an L processor is required

Server support

Intel Optane DC Persistent Memory is only supported in servers with second-generation Intel Xeon Scalable processors. The following table lists the ThinkSystem servers that are compatible.

The following tables list the ThinkSystem servers that are compatible.

Table 10. Server support (Part 1 of 5)

Part Number	Description	SR635 V3 (7D9H / 7D9G)	SR655 V3 (7D9F / 7D9E)	SR645 V3 (7D9D / 7D9C)	SR665 V3 (7D9B / 7D9A)	ST650 V3 (7D7B / 7D7A)	SR630 V3 (7D72 / 7D73)	SR650 V3 (7D75 / 7D76)	SR630 V4 (7DG8 / 7DG9)	SR650 V4 (7DGC / 7DGD)	SR650a V4 (7DGC / 7DGD)	SD535 V3 (7DD8 / 7DD1)	SD530 V3 (7DDA / 7DD3)	SD550 V3 (7DD9 / 7DD2)	ST45 V3 (7DH4 / 7DH5)	ST50 V3 (7DF4 / 7DF3)	ST250 V3 (7DCF / 7DCE)	SR250 V3 (7DCM / 7DCL)
		AMD V3				**2S Intel V3/V4**						**Multi Node V3/V4**			**1S V3**			
4ZC7A15110	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4ZC7A15111	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4ZC7A15112	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Table 11. Server support (Part 2 of 5)

Part Number	Description	4S 8S Intel V3/V4					GPU Rich						Edge					
		SR850 V3 (7D97 / 7D96)	SR860 V3 (7D94 / 7D93)	SR950 V3 (7DC5 / 7DC4)	SR850 V4 (7DJT / 7DJS)	SR860 V4 (7DJQ / 7DJN)	SR670 V2 (7Z22 / 7Z23)	SR675 V3 (7D9Q / 7D9R)	SR680a V3 (7DHE)	SR680a V3 B200 (7DM9)	SR685a V3 (7DHC)	SR780a V3 (7DJ5)	SE100 (7DGR)	SE350 (7Z46 / 7D1X)	SE350 V2 (7DA9)	SE360 V2 (7DAM)	SE450 (7D8T)	SE455 V3 (7DBY)
4ZC7A15110	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4ZC7A15111	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4ZC7A15112	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Table 12. Server support (Part 3 of 5)

Part Number	Description	Super Computing							1S Intel V2			2S Intel V2			AMD V1				
		SC750 V4 (7DDJ)	SC777 V4 (7DKA)	SD665 V3 (7D9P)	SD665-N V3 (7DAZ)	SD650 V3 (7D7M)	SD650-I V3 (7D7L)	SD650-N V3 (7D7N)	ST50 V2 (7D8K / 7D8J)	ST250 V2 (7D8G / 7D8F)	SR250 V2 (7D7R / 7D7Q)	ST650 V2 (7Z75 / 7Z74)	SR630 V2 (7Z70 / 7Z71)	SR650 V2 (7Z72 / 7Z73)	SR635 (7Y98 / 7Y99)	SR655 (7Y00 / 7Z01)	SR655 Client OS	SR645 (7D2Y / 7D2X)	SR665 (7D2W / 7D2V)
4ZC7A15110	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4ZC7A15111	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
4ZC7A15112	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Table 13. Server support (Part 4 of 5)

Part Number	Description	Dense V2					4S V2	8S	4S V1			1S Intel V1			
		SD630 V2 (7D1K)	SD650 V2 (7D1M)	SD650-N V2 (7D1N)	SN550 V2 (7Z69)	SR850 V2 (7D31 / 7D32)	SR860 V2 (7Z59 / 7Z60)	SR950 (7X11 / 7X12)	SR850 (7X18 / 7X19)	SR850P (7D2F / 2D2G)	SR860 (7X69 / 7X70)	ST50 (7Y48 / 7Y50)	ST250 (7Y45 / 7Y46)	SR150 (7Y54)	SR250 (7Y52 / 7Y51)
4ZC7A15110	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N
4ZC7A15111	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N
4ZC7A15112	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N

Table 14. Server support (Part 5 of 5)

Part Number	Description	2S Intel V1								Dense V1			
		ST550 (7X09 / 7X10)	SR530 (7X07 / 7X08)	SR550 (7X03 / 7X04)	SR570 (7Y02 / 7Y03)	SR590 (7X98 / 7X99)	SR630 (7X01 / 7X02)	SR650 (7X05 / 7X06)	SR670 (7Y36 / 7Y37)	SD530 (7X21)	SD650 (7X58)	SN550 (7X16)	SN850 (7X15)
4ZC7A15110	ThinkSystem 128GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	Y	Y	Y	Y	N	Y	N	Y	Y
4ZC7A15111	ThinkSystem 256GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	Y	Y	Y	Y	N	Y	N	Y	Y
4ZC7A15112	ThinkSystem 512GB TruDDR4 2666MHz (1.2V) Intel Optane DC Persistent Memory	N	N	N	Y	Y	Y	Y	N	Y	N	Y	Y

Most ThinkSystem servers have 12 DIMM slots per processor and 2 DIMMs per channel across all channels, thereby supporting 1 DCPMM in every memory channel. However, some servers have fewer slots, and as a result, not all combinations of DIMMs and DCPMMs are supported.

When all 12 DIMMs are installed, this is referred to as a "2-2-2" configuration, where each 2 corresponds to the number of DIMMs per channel in 1 memory controller. When fewer DIMMs are installed, it is referred to a "2-2-1" or "2-1-1" or similar. The table shows with combinations are supported with each ThinkSystem server.

Table 15. DIMM slots per processor

Server	DIMM slots total	Number of DCPMMs supported	2-2-2 support	2-2-1 support	2-1-1 support	1-1-1 support
SR570 (7Y02/7Y03)	16	4	No	No	Yes	Yes
SR590 (7X98/7X99)	16	4	No	No	Yes	Yes
SR630 (7X01/7X02)	24	12	Yes	Yes	Yes	Yes
SR650 (7X05/7X06)	24	12	Yes	Yes	Yes	Yes
SR850 (7X18/7X19)	48	24	Yes	Yes	Yes	Yes
SR860 (7X69/7X70)	48	24	Yes	Yes	Yes	Yes
SR950 (7X11/12/13)	96	48	Yes	Yes	Yes	Yes
SD530 (7X21)	16 or 12*	4 (16 only)	No	No	Yes (16 only)	Yes
SD650 (7X58)	12+4**	4	No	No	Yes	Yes
SN550 (7X16)	24	12	Yes	Yes	Yes	Yes
SN850 (7X15)	24	12	Yes	Yes	Yes	Yes

* For the SD530, 16 slots are available only when the narrow processor heatsink is used
** The SD650 has 16 DIMM slot total, 4 of which are reserved for use with DCPMMs

Operating system support

The following operating systems support the use of persistent memory modules:

- Microsoft Windows Server 2019
- Red Hat Enterprise Linux 7.6
- SUSE Linux Enterprise Server 12.4
- SUSE Linux Enterprise Server 15
- VMware vSphere Hypervisor (ESXi) 6.7 U1
- Ubuntu LTS 18.04

For details about VMware support, see these VMware KB articles:

- Lenovo DCPMM ESXi support
- VMware ESXi DCPMM support

Warranty

The ThinkSystem Intel Optane DC Persistent Memory Modules carry a 1-year limited warranty. When installed in a supported ThinkSystem server, the DCPMMs assume the server's base warranty and any warranty upgrades.

Resources

The following papers have been published on the use of Persistent Memory:

- *Implementing Intel Optane DC Persistent Memory on Windows Server 2019*
  https://lenovopress.com/LP1192

- *Enabling Intel Optane DC Persistent Memory in a Linux Virtual Machine*
  https://lenovopress.com/LP1224

- *Implementing Intel Optane DC Persistent Memory with VMware vSphere*
  https://lenovopress.com/LP1225

- *Introducing the Programming Model of Intel Optane DC Persistent Memory*
  https://lenovopress.com/LP1194

- *Analyzing the Performance of Intel Optane DC Persistent Memory in App Direct Mode in Lenovo ThinkSystem Servers*
  https://lenovopress.com/LP1083

- *Analyzing the Performance of Intel Optane DC Persistent Memory in Memory Mode in Lenovo ThinkSystem Servers*
  https://lenovopress.com/LP1084

- *Analyzing the Performance of Intel Optane DC Persistent Memory in Storage over App Direct Mode*
  https://lenovopress.com/LP1085

For more information, see these additional web resources:

- Lenovo web page for Persistent Memory
  https://www.lenovo.com/us/en/data-center/servers/server-options/thinksystem-options/Intel-Optane-DC-Persistent-Memory/p/WMD00000388

- Intel Optane DC Persistent Memory web page
  https://www.intel.com/content/www/us/en/architecture-and-technology/optane-dc-persistent-memory.html

- Intel Optane Technology web page:
  https://www.intel.com/content/www/us/en/architecture-and-technology/intel-optane-technology.html

- Lenovo ThinkSystem Information Center (User Manuals):
    - DCPMM installation order
    - DCPMM setup
    - Adding memory modules with DCPMMs
    - Configuring DCPMMs

Related product families

Product families related to this document are the following:

- Memory

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