Technical white paper



Server memory population rules for HPE ProLiant Gen11 servers with AMD EPYC 8004/9004 series processors

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Introduction

This paper provides an overview of HPE DDR5 SmartMemory and its use in HPE ProLiant servers using the AMD EPYC™ 8004/9004 processor family. HPE ProLiant servers with AMD EPYC 8004/9004 introduce HPE DDR5-4800 memory, which has faster data rates, lower latencies, and greater power efficiency than the memory used in previous generations of HPE ProLiant servers. HPE SmartMemory also provides superior performance over third-party memory when used in HPE ProLiant servers.

In addition to describing these improvements, this white paper reviews the rules, best practices, and optimization strategies that should be used when installing HPE DDR5-4800 on an HPE ProLiant Gen11 with a 8004/9004 processor.

Populating HPE DDR5 memory in HPE ProLiant Gen11 servers with AMD EPYC 8004/9004 processors

The high-level memory system architecture for HPE ProLiant Gen11 servers using AMD EPYC 8004/9004 processors is different from that of the previous HPE ProLiant servers. HPE ProLiant servers using AMD EPYC 8004 & 9004 processors integrate an IOD chip, which includes 6 & 12 memory controllers to interface 6 & 12 memory channels per CPU and up to 6 & 24 DIMM slots in one & two-socket servers.

Population rules for HPE ProLiant Gen11 servers with AMD EPYC 8004/9004 processors

HPE ProLiant Gen11 systems support a variety of flexible server memory configurations, enabling the system to be configured and run in any valid memory controller configuration. For optimal performance and functionality, you should follow the rules when populating HPE ProLiant servers with HPE DDR5 memory. Violating these rules may result in reduced memory capacity, performance, or error messages during boot. Table 1 summarizes the overall DIMM population rules for HPE ProLiant Gen11 servers.

Table 1. DIMM population rules for HPE ProLiant Gen11 servers

Category	Population guidelines
Processors and DIMM slots	For AMD EPYC 9004: One or two CPU socket in a system, one DIMM per channel (DPC). install DIMMs only if the corresponding processor is installed. If only one processor is installed in a two-processor system, then only half of the DIMM slots are available. If multiple CPUs are populated, split the DIMMs evenly across the CPUs and follow the corresponding CPU rule when populating DIMMs. For AMD EPYC 8004: Only 1 CPU socket in a system, one DIMM per channel (DPC), populate white DIMM slots only.
Performance	To maximize performance in a majority of the potential applications, it is recommended to balance the total memory capacity across all installed processors, channel pairs (A/G, C/I, B/H, E/K, D/J, F/I) for 9004 series, channel pairs (A/E, D/H, B/F) for 8004 series. Load the channels similarly whenever possible to enable optimal interleaving. If the number of DIMMs does not spread evenly across the CPUs, populate as close to evenly as possible.
DIMM types and capacities	The maximum memory capacity is a function of the number of DIMM slots on the platform: the largest DIMM capacity qualified on the platform and the number and model of qualified processors installed on the platform. Do not mix RDIMMs and LRDIMMs in the same system. Do not mix 3DS DIMMs with non-3DS DIMMs in the same system. Do not mix x4 and x8 DRAM widths in the same system. Don't mix 16 GB, 24 GB, and 32 GB DRAM width with each other, like mixing 24 GB and 16 GB or 16 GB and 32 GB DRAM widths in the same system, It's not allowed. Unbuffered DIMMs (UDIMMs) are not supported.
DIMM speed	The maximum memory speed is a function of the memory type, memory configuration, and processor model. The server will select the highest common speed among all the DIMMs present in the system.

There are several HPE ProLiant Gen11 servers with different EPYC series. Figure 1 shows the EPYC series on each HPE ProLiant DL Gen11 server series.

DIMM connector location

In general, memory population order follows the same logic for all HPE ProLiant servers using AMD EPYC 8004 and 9004 processors — although physical arrangement may vary from server to server.

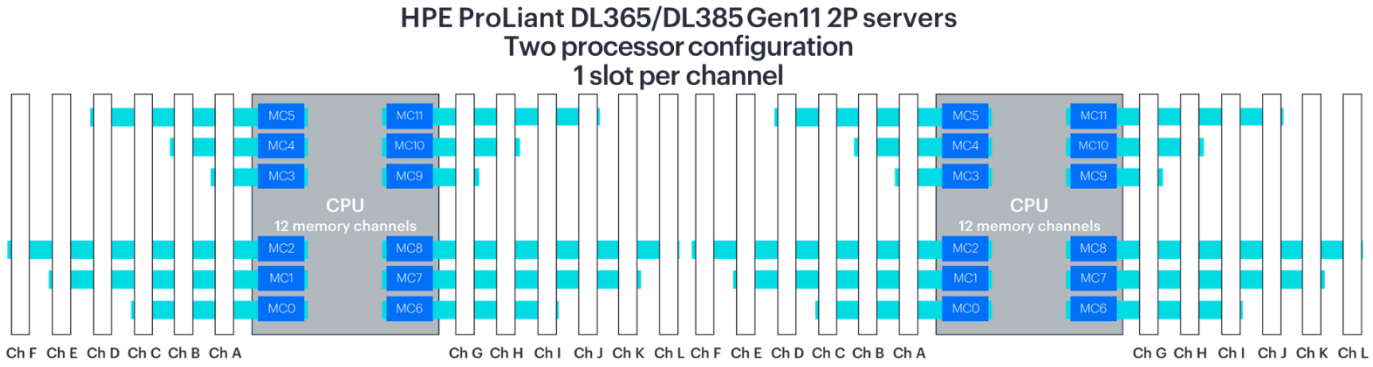


Figure 1. DIMM slot locations for AMD EPYC 9004 with 24-slot in HPE ProLiant DL365/DL385 Gen11 two-socket configuration

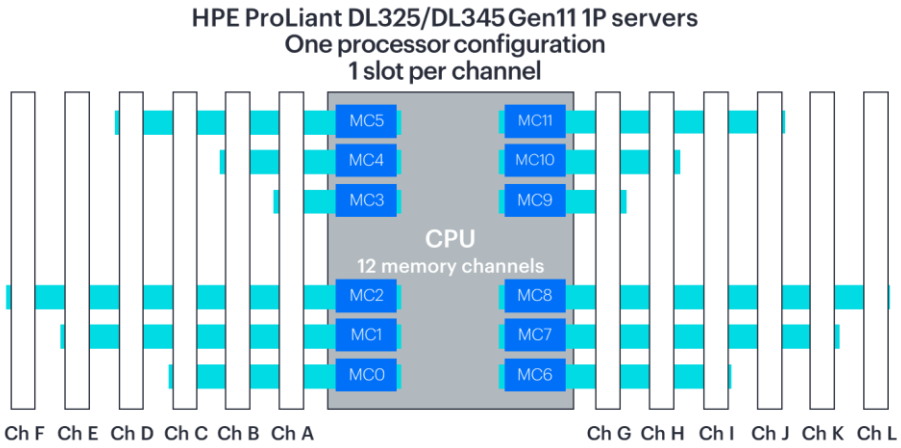


Figure 2. DIMM slot locations for AMD EPYC 9004 with 12-slot in HPE ProLiant DL325/DL345 Gen11 one-socket servers

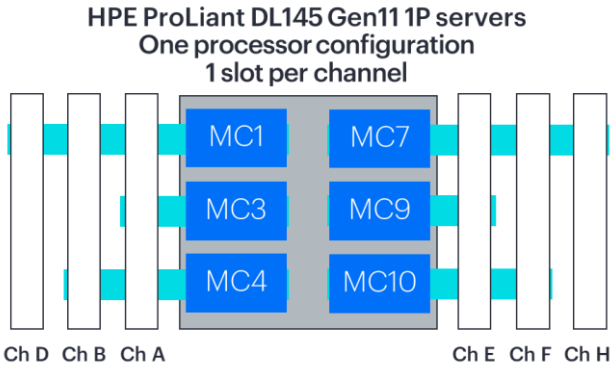


Figure 3. DIMM slot locations for AMD EPYC 8004 with 6-slot in HPE ProLiant DL145 Gen11 only one-socket servers

DIMM population order

Tables 2 and 3 show the DIMM population order for HPE ProLiant Gen11 servers with one AMD EPYC 9004 processor installed. There are 12 DIMM slots available to be populated per CPU socket. For a given number of DIMMs, populate those DIMMs in the corresponding numbered DIMM slots on the particular row based on server model as shown in Tables 2 and 3. The most optimal performance will be achieved if populating full DIMMs, HPE Server Memory should be installed as indicated based on the total number of DIMMs being installed per CPU. For example, if two DIMMs are being installed per CPU on an HPE ProLiant DL365/DL385 series 2P, they should be located in white DIMM slots numbered 6 and 7. If six DIMMs are being used per CPU, they should be installed in DIMM slots 4, 5, 6, 7, 8, and 9.

Table 4 show the DIMM population order for HPE ProLiant Gen11 servers with one AMD EPYC 8004 processor installed. There are 6 DIMM slots available to be populated per CPU socket. For a given number of DIMMs, populate those DIMMs in the corresponding numbered DIMM slots on the particular row based on server model as shown in Table 4. The most optimal performance will be achieved if populating full DIMMs, HPE Server Memory should be installed as indicated based on the total number of DIMMs being installed per CPU. For example, if two DIMMs are being installed per CPU on an HPE ProLiant DL145, they should be located in white DIMM slots numbered 3 and 4. If four DIMMs are being used per CPU, they should be installed in DIMM slots 1, 3, 4 and 6.

Table 2. DIMM population order for HPE ProLiant DL DL325/DL345 1P Gen11 server series with one processor installed (12 slots per processor)

MD EPYC 9004 in HPE ProLiant DL325/DL345 Gen11 series — one-processor configuration Homogeneous DIMMs												
Population order Number of DIMMs	Processor 1											
	L	K	J	I	H	G	A	B	C	D	E	F
1							6					
2						7	6					
4				9		7	6		4			
6				9	8	7	6	5	4			
8		11		9	8	7	6	5	4		2	
10		11	10	9	8	7	6	5	4	3	2	
12	12	11	10	9	8	7	6	5	4	3	2	1

Table 3. DIMM population order for AMD EPYC 9004 in HPE ProLiant DL DL365/DL385 2P Gen11 server series with two processors installed (12 slots per processor)

AMD EPYC 9004 in HPE ProLiant DL365/DL385 Gen11 series — two-processor configuration Homogeneous DIMMs population order																								
Number of DIMMs	Processor 2												Processor 1											
	F	E	D	C	B	A	G	H	I	J	K	L	F	E	D	C	B	A	G	H	I	J	K	L
2						7												7						
4						7	6											7	6					
8				9		7	6		4							9		7	6		4			
12				9	8	7	6	5	4							9	8	7	6	5	4			
16			11		9	8	7	6	5	4		2			11		9	8	7	6	5	4		2	
20			11	10	9	8	7	6	5	4	3	2			11	10	9	8	7	6	5	4	3	2	
24		12	11	10	9	8	7	6	5	4	3	2	1	12	11	10	9	8	7	6	5	4	3	2	1

Table 4. DIMM population order for AMD EPYC 8004 in HPE ProLiant DL145 1P Gen11 server series with one processor installed (6 slots per processor)

HPE ProLiant AMD EPYC 8004 in DL145 Gen11 series — two-processor configuration Homogeneous DIMMs population order HPE ProLiant DL145 series Gen11 — One Processor Configuration Homogeneous DIMM(s) Population Order Number of DIMM(s)						
	D	B	A	E	F	H
1			4			
2			4	3		
4	6		4	3		1
6	6	5	4	3	2	1

NUMA nodes

HPE ProLiant servers with EPYC 8004/9004 processors may support the option of configuring the non-uniform memory access (NUMA) nodes per socket (NPS) you can have on the processor. This will depend on the exact model number of the processor. This setting will be available in the RBSU->Memory Options->NUMA memory domains per socket (1, 2, 4). For most workloads, one NUMA node will give the most optimal performance and is the default.

Nodes per socket (1) NPS1

This setting will assign one NUMA node per processor.

This setting will be the default, and in general, will give the best performance for most workloads.

Nodes per socket (2) NPS2

This setting will assign two NUMA nodes per processor.

Nodes per socket (4) NPS4

This setting will assign four NUMA nodes per processor.

Memory interleaving

Memory interleaving is a technique used to maximize memory performance by spreading memory addresses evenly across memory devices. Interleaved memory results in a contiguous memory region across multiple devices with sequential accesses using each memory device in turn, instead of using the same one repeatedly. HPE encourages enabling interleaving for the most optimal and deterministic performance. The result is higher memory throughput due to the reduced wait times for memory banks to become available for desired operations between reads and writes.

Table 5 shows Interleaving with NUMA (Default NPS1, NPS2, NPS4) per population on HPE ProLiant DL 1P Gen11 server

Table 6 shows Interleaving with NUMA (Default NPS1, NPS2, NPS4) per population on HPE ProLiant DL 2P Gen11 server.

Table 7 shows Interleaving with NUMA (Default NPS1, NPS2, NPS4) per population on HPE ProLiant DL145 Gen11 server.

Table 5. Interleaving with NUMA (Default NPS1, NPS2, NPS4) per population for AMD EPYC 9004 in HPE ProLiant DL325/345 1P Gen11 server series with one processor installed (12 slots per processor)

Number of DIMM(s)	Interleaving with NUMA (Default NPS1, NPS2, NPS4)
1	NPS1 (No interleaving)
2	NPS1 (2-way interleaving), NPS2 (No interleaving)
4	NPS1 (4-way interleaving), NPS2 (2-way interleaving), NPS4 (No interleaving)
6	NPS1 (6-way interleaving), NPS2 (3-way interleaving)
8	NPS1 (8-way interleaving), NPS2 (4-way interleaving), NPS4 (2-way interleaving)
10	NPS1 (10-way interleaving), NPS2 (5-way interleaving)
12	NPS1 (12-way interleaving), NPS2 (6-way interleaving), NPS4 (3-way interleaving)

Table 6. Interleaving with NUMA (Default NPS1, NPS2, NPS4) per population for AMD EPYC 9004 in HPE ProLiant DL365/385 2P Gen11 server series with two processors installed (12 slots per processor)

Number of DIMM(s)	Interleaving with NUMA (Default NPS1, NPS2, NPS4)
2	NPS1 (No interleaving)
4	NPS1 (2-way interleaving), NPS2 (No interleaving)
8	NPS1 (4-way interleaving), NPS2 (2-way interleaving), NPS4 (No interleaving)
12	NPS1 (6-way interleaving), NPS2 (3-way interleaving)
16	NPS1 (8-way interleaving), NPS2 (4-way interleaving), NPS4 (2-way interleaving)
20	NPS1 (10-way interleaving), NPS2 (5-way interleaving),
24	NPS1 (12-way interleaving), NPS2 (6-way interleaving), NPS4 (3-way interleaving)

Table 7. Interleaving with NUMA (Default NPS1, NPS2, NPS4) per population for AMD EPYC 8004 HPE ProLiant DL 145 1P Gen11 server series with two processors installed (6 slots per processor)

Number of DIMM(s)	Interleaving with NUMA (Default NPS1, NPS2, NPS4)
1	NPS1 (No interleaving)
2	NPS1 (2-way interleaving), NPS2 (No interleaving)
4	NPS1 (4-way interleaving), NPS2 (2-way interleaving), NPS4 (No interleaving)
6	NPS1 (6-way interleaving), NPS2 (3-way interleaving)

Disabling memory interleaving

This option is available from the Advanced Power Management menu in the RBSU Memory Options menu if needed. HPE defaults to having interleaving enabled, as this will provide the best performance for most workloads. Disabling memory interleaving may decrease overall memory performance.

Mixed DIMM configurations

3DS DIMM and RDIMM should not be mixed (as per specification), as timings for these are significantly different; hence, the operation is reduced to the slowest common timing.

No mixing of x4 and x8 memory, as it will cause slower memory and system operation.

No mixing of 16 GB, 24 GB, and 32 GB DRAM, as it will cause slower memory and system operation.

On HPE servers based on AMD processors, mixing of DIMM capacities is supported as long as mixing rules are followed and the memory channels have identical memory capacities to get the most performance.

Table 8. Impact of unbalanced configurations on memory throughput on AMD EPYC 9004 processors

Number of interleaved channels per processor		Throughput compared to peak
DIMMs	Large group	Weighted channel performance in %
1	1	8.3%
2	2	16.6%
4	4	33.3%
6	6	50%
8	8	66.6%
10	10	83.3%
12	12	100%

Table 9. Impact of unbalanced configurations on memory throughput on AMD EPYC 8004 processors

Number of interleaved channels per processor		Throughput compared to peak
DIMMs	Large group	Weighted channel performance in %
1	1	16.6%
2	2	33.3%
4	4	50%
6	6	100%

Table 10. Memory speed table for HPE Gen11 300 series platforms

Registered DIMM (RDIMM)									
HPE SKU P/N	**P50309-B21**	**P50310-B21**	**P50311-B21**	**P50312-B21**	**P66676-B21**	**P69982-B21**	**P50313-B21**	**P50314-B21**	**P90552-B21**
SKU description	HPE 16GB 1Rx8 PC5-4800B-R Smart Kit	HPE 32GB 1Rx4 PC5-4800B-R Smart Kit	HPE 32GB 2Rx8 PC5-4800B-R Smart Kit	HPE 64GB 2Rx4 PC5-4800B-R Smart Kit	HPE 96GB 2Rx4 PC5-4800B-R Smart Kit	HPE 128GB 2Rx4 PC5-4800B-R Smart Kit	HPE 128GB 4Rx4 PC5-4800B-R 3DS Smart Kit	HPE 256GB 8Rx4 PC5-4800B-R 3DS Smart Kit	HPE 256GB 4Rx4 PC5-4800B-R 3DS Smart Kit
DIMM rank ->	Single Rank (1R)	Single Rank (1R)	Dual Rank (2R)	Dual Rank (2R)	Dual Rank (2R)	Dual Rank (2R)	Quad Rank (4R)	Octal Rank (8R)	Quad Rank (4R)
DIMM capacity ->	**16 GB**	**32 GB**	**32 GB**	**64 GB**	**96 GB**	**128GB**	**128 GB**	**256 GB**	**256 GB**
Voltage	1.1V	1.1V	1.1V	1.1V	1.1V	1.1V	1.1V	1.1V	1.1V
DRAM depth (bit)	2G	4G	2G	4G	4G	8G	4G	4G	8G
DRAM width (bit)	x8	x4	x8	x4	x4	x4	x4	x4	x4
DRAM density	16 Gb	16 Gb	16 Gb	16 Gb	16 Gb	32 Gb	16 Gb	16 Gb	32 Gb
CAS latency	42-42-42	42-42-42	42-42-42	42-42-42	46-45-45	46-45-45	50-42-42	50-42-42	60-52-52
DIMM native speed (MT/s)	4800	4800	4800	4800	4800	4800	4800	4800	4800
AMD EPYC® 9004 Series Processor Officially Supported Memory Speed (MT/s)*									
1 DIMM per channel	4800	4800	4800	4800	4800	4800	4800	4800	4800
2 DIMM per channel	NA	NA	NA	NA	NA	NA	NA	NA	NA
HPE Server Memory Speed (MT/s): With AMD EPYC® 9004 Series Processor*									
1 DIMM per channel	4800	4800	4800	4800	4800	4800	4800	4800	4800
2 DIMM per channel	NA	NA	NA	NA	NA	NA	NA	NA	NA

* The maximum memory speed is a function of the memory type, memory configuration, and processor model.

Table 11. Memory speed table for HPE Gen11 145 platforms

Registered DIMM (RDIMM)					
HPE SKU P/N	**P50309-B21**	**P50311-B21**	**P50312-B21**	**P66676-B21**	**P69982-B21**
SKU description	HPE 16GB 1Rx8 PC5-4800B-R Smart Kit	HPE 32GB 2Rx8 PC5-4800B-R Smart Kit	HPE 64GB 2Rx4 PC5-4800B-R Smart Kit	HPE 96GB 2Rx4 PC5-4800B-R Smart Kit	HPE 128GB 2Rx4 PC5-4800B-R Smart Kit
DIMM rank ->	Single Rank (1R)	Dual Rank (2R)	Dual Rank (2R)	Dual Rank (2R)	Dual Rank (2R)
DIMM capacity ->	**16 GB**	**32 GB**	**64 GB**	**96 GB**	**128 GB**
Voltage	1.1V	1.1V	1.1V	1.1V	1.1V
DRAM depth [bit]	2G	2G	4G	4G	8G
DRAM width [bit]	x8	x8	x4	x4	x4
DRAM density	16 GB	16 GB	16 GB	24 GB	32 GB
CAS latency	42-42-42	42-42-42	42-42-42	46-45-45	46-45-45
DIMM native speed (MT/s)	4800	4800	4800	4800	4800
AMD EPYC® 8004 Series Processor Officially Supported Memory Speed (MT/s)*					
1 DIMM per channel	4800	4800	4800	4800	4800
2 DIMM per channel	NA	NA	NA	NA	NA
HPE Server Memory Speed (MT/s): With AMD EPYC® 8004 Series Processor*					
1 DIMM per channel	4800	4800	4800	4800	4800
2 DIMM per channel	NA	NA	NA	NA	NA

* The maximum memory speed is a function of the memory type, memory configuration, and processor model.

Table 12. Mixed population guidelines for HPE SmartMemory DIMMs

AMD 9004 DDR5										
P/N	Description	P50309-X21	P50310-X21	P50311-X21	P50312-X21	P66676-X21	P69982-X21	P50313-X21	P50314-X21	P90552-X21
		16 GB 1Rx8	32 GB 1Rx4	32 GB 2Rx8	64 GB 2Rx4	96 GB 2Rx4	128 GB 2Rx4	128 GB 4Rx4 2H3DS	256 GB 8Rx4 4H3DS	256 GB 4Rx4 2H3DS
		16 Gbit	16 Gbit	16 Gbit	16 Gbit	24 Gbit	32 Gbit	16 Gbit	16 Gbit	32 Gbit
		4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s
		RDIMM	RDIMM	RDIMM	RDIMM	RDIMM	RDIMM	RDIMM	RDIMM	RDIMM
P50309-X21	HPE 16GB 1Rx8 PC5-4800B-R Smart Kit	Yes	No[2]	Yes	No[2]	No[1, 2, 3]	No[2, 3]	No[1, 2, 3]	No[1, 2, 3]	No[1, 2, 3]
P50310-X21	HPE 32GB 1Rx4 PC5-4800B-R Smart Kit	No[2]	Yes	No[2]	Yes	No[3]	No[3]	No[1, 3]	No[1, 3]	No[1, 3]
P50311-X21	HPE 32GB 2RX8 PC5-4800B-R Smart Kit	Yes	No[2]	Yes	No[2]	No[1, 2, 3]	No[1, 2, 3]	No[1, 2, 3]	No[1, 2, 3]	No[1, 2, 3]
P50312-X21	HPE 64GB 2RX4 PC5-4800B-R Smart Kit	No[2]	Yes	No[2]	Yes	No[3]	No[3]	No[1, 3]	No[1, 3]	No[1, 3]
P66676-X21	HPE 96GB 2RX4 PC5-4800B-R Smart Kit	No[1, 2, 3]	No[3]	No[1, 2, 3]	No[3]	Yes	No[3]	No[1, 3]	No[1, 3]	No[3]
P69982-X21	HPE 128GB 2RX4 PC5-4800B-R Smart Kit	No[2, 3]	No[3]	No[2, 3]	No[3]	No[3]	Yes	No[1, 3]	No[1, 3]	No[3]
P50313-X21	HPE 128GB 4RX4 PC5-4800B-R 3DS Smart Kit	No[1, 2, 3]	No[1, 3]	No[1, 2, 3]	No[1, 3]	No[1, 3]	No[1, 3]	Yes	Yes	No[3]
P50314-X21	HPE 256GB 8RX4 PC5-4800B-R 3DS Smart Kit	No[1, 2, 3]	No[1, 3]	No[1, 2, 3]	No[1, 3]	No[1, 3]	No[1, 3]	Yes	Yes	No[3]
P90552-X21	HPE 256GB 4RX4 PC5-4800B-R 3DS Smart Kit	No[1, 2, 3]	No[1, 3]	No[1, 2, 3]	No[1, 3]	No[1, 3]	No[1, 3]	No[3]	No[3]	Yes

[1] Do not mix DIMM module types. All DIMMs must be RDIMM or 3DS RDIMM module types, with same ECC configuration.
[2] x4 cannot be mixed with x8 within the same system.
[3] Mixing DIMMs built with different DRAM densities (i.e. 16Gb, 24Gb, and 32Gb DRAMs) within a system is not supported.

Table 13. Mixed population guidelines for HPE SmartMemory DIMMs

AMD 8004 DDR5						
P/N	Description	P50309-X21	P50311-X21	P50312-X21	P66676-X21	P69982-X21
		16 GB 1Rx8	32 GB 2Rx8	64 GB 2Rx4	96 GB 2Rx4	128 GB 2Rx4
		16 Gbit	16 Gbit	16 Gbit	24 Gbit	32 Gbit
		4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s	4800 MT/s
		RDIMM	RDIMM	RDIMM	RDIMM	RDIMM
P50309-X21	HPE 16GB 1Rx8 PC5-4800B-R Smart Kit	Yes	Yes[6]	No[4]	No[4]	No[4]
P50311-X21	HPE 32GB 2RX8 PC5-4800B-R Smart Kit	Yes[6]	Yes	No[4]	No[4]	No[4]
P50312-X21	HPE 64GB 2RX4 PC5-4800B-R Smart Kit	No[4]	No[4]	Yes	No[5]	No[5]
P66676-X21	HPE 96GB 2RX4 PC5-4800B-R Smart Kit	No[4]	No[4]	No[5]	Yes	No[5]
P69982-X21	HPE 128GB 2RX4 PC5-4800B-R Smart Kit	No[4]	No[4]	No[5]	No[5]	Yes

[4] x4 cannot be mixed with x8 within the same system
[5] Mixing DIMMs of different DRAM density (that is, 8 GB, 16 GB, 24 GB, and 32 GB DRAMs) within a system is not supported.
[6] Mixing DIMM capacities within a system is supported as long as they are same DIMM type (same x4 or same x8)

Conclusion

HPE SmartMemory for HPE ProLiant Gen11 AMD-based servers offers greater memory performance than ever before. The HPE DDR5-4800 SmartMemory for HPE ProLiant Gen11 servers that use the AMD EPYC 8004/9004 processor delivers increased memory throughput and lower latencies. HPE SmartMemory also provides extended performance in many configurations by operating at higher speeds compared to third-party memory.

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