Hewlett Packard Enterprise

Technical white paper

Population rules for DIMMs in HPE Gen10 servers with Intel Xeon Scalable processors

Contents

Introduction

This paper describes how to populate HPE DDR4 SmartMemory DIMMs and HPE DDR4 NVDIMM-Ns in HPE ProLiant Gen10 servers and Synergy Gen10 compute modules using Intel® Xeon® scalable processors. HPE server memory for Gen10 servers support faster data rates, lower latencies, and greater power efficiency than the DIMMs used in previous generations of HPE servers. HPE SmartMemory also provides superior performance over third-party memory when used in HPE servers.

HPE Gen10 servers with Intel Xeon processors offer the same number of DIMM slots as HPE Gen9 servers, but the central processing unit (CPU) architecture has changed:

- Gen10: Six memory channels per CPU with up to two DIMM slots per channel (12 DIMM slots per channel)
- Gen9: Four memory channels per CPU with up to three DIMM slots per channel (12 DIMM slots per channel)

This improves nominal bandwidth by 50% if all channels are used. In conjunction with increasing the memory speed to from 2400 MT/s to 2666 MT/s, this improves nominal bandwidth by 66% (76.8 GB/s to 128 GB/s).

In addition to describing these improvements, this white paper reviews the rules, best practices, and optimization strategies that should be used when installing HPE DDR4 DIMMs in HPE Gen10 servers.

Populating HPE DDR4 DIMMs in HPE Gen10 servers

HPE Gen10 systems support a variety of flexible 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 Gen10 servers with HPE DDR4 DIMMs. Violating these rules may result in reduced memory capacity, performance, or error messages during boot. Table 1 summarizes the overall population rules for HPE Gen10 servers.

Table 1. DIMM population rules for HPE Gen10 servers

Category	Population guidelines
Processors and DIMM slots	Install DIMMs only if the corresponding processor is installed. If only one processor is installed in a two-processor system, only half of the DIMM slots are available. If a memory channel consists of more than one DIMM slot, the white DIMM slot is located furthest from the CPU. White DIMM slots denote the first slot to be populated in a channel. For one DIMM per channel (DPC) populate white DIMM slots only. When mixing HPE SmartMemory DIMMs of different ranks on the same channel, place the HPE SmartMemory DIMM with the higher number of ranks in the white DIMM slot and the HPE SmartMemory DIMM with the lower number of ranks in the black DIMM slot. If multiple CPUs are populated, split the HPE SmartMemory DIMMs evenly across the CPUs and follow the corresponding CPU rules when populating DIMMs.
Performance	To maximize performance, it is recommended to balance the total memory capacity across all installed processors and load the channels similarly whenever possible (see Appendix B). If the number of DIMMs does not spread evenly across the CPUs, populate as close to evenly as possible. Avoid creating an unbalanced configuration for any CPU.
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 HPE SmartMemory RDIMMs and HPE SmartMemory LRDIMMs in the same system. Do not mix HPE SmartMemory 128 GB LRDIMMs with other capacity HPE SmartMemory LRDIMMs. HPE servers do not support unbuffered DIMMs (UDIMMs). HPE SmartMemory DIMMs with x4 and x8 DRAMs can be mixed in the same channel. RAS features affected when mixing x4 and x8 DIMMs are Online Spare, Mirrored Memory, and HPE Fast Fault Tolerance.
DIMM speed	The maximum memory speed is a function of the memory type, memory configuration, and processor model. DIMMs of different speeds may be mixed in any order; however, the server will select the highest common speed among all of the DIMMs on all of the CPU. HPE SmartMemory DIMMs and HPE NVDIMM-Ns from previous generation servers are not compatible with the current generation. Certain HPE SmartMemory features such as Memory Authentication and Enhanced Performance may not be supported.
Heterogeneous mix	There are no performance implications for mixing sets of different capacity DIMMs at the same operating speed. For example, latency and throughput will not be negatively impacted by installing an equal number of 16 GB dual-rank DDR4-2666 DIMMs (one per channel) and 32 GB dual-rank DDR4-2666 DIMMs (one per channel). Take each DIMM type and create a configuration as if it were a homogeneous configuration.

Introduction to DIMM slot locations

In general, DIMM population order follows the same logic for all HPE Gen10 servers—although physical arrangement may vary from server to server. To populate DIMMs in the correct order and location, refer to illustrations found in Appendix B for HPE SmartMemory DIMMs and Appendix C for HPE NVDIMM-Ns. Each illustration reflects the DIMM slots to use for a given number of DIMMs around a single processor, assuming a common DIMM type.

If multiple processors are installed, split the DIMMs evenly across the processors and follow the corresponding rule when populating DIMMs for each processor (see Figure 7 for an example). For optimal throughput and reduced latency, populate all six channels of each installed CPU identically.

The first DIMM slots for each channel have white connectors and the second DIMM slots, if any, have black connectors.

Figure 1 shows the DIMM slot configuration for the HPE ProLiant DL380 Gen10 servers, which have two sockets and 24 DIMM slots.

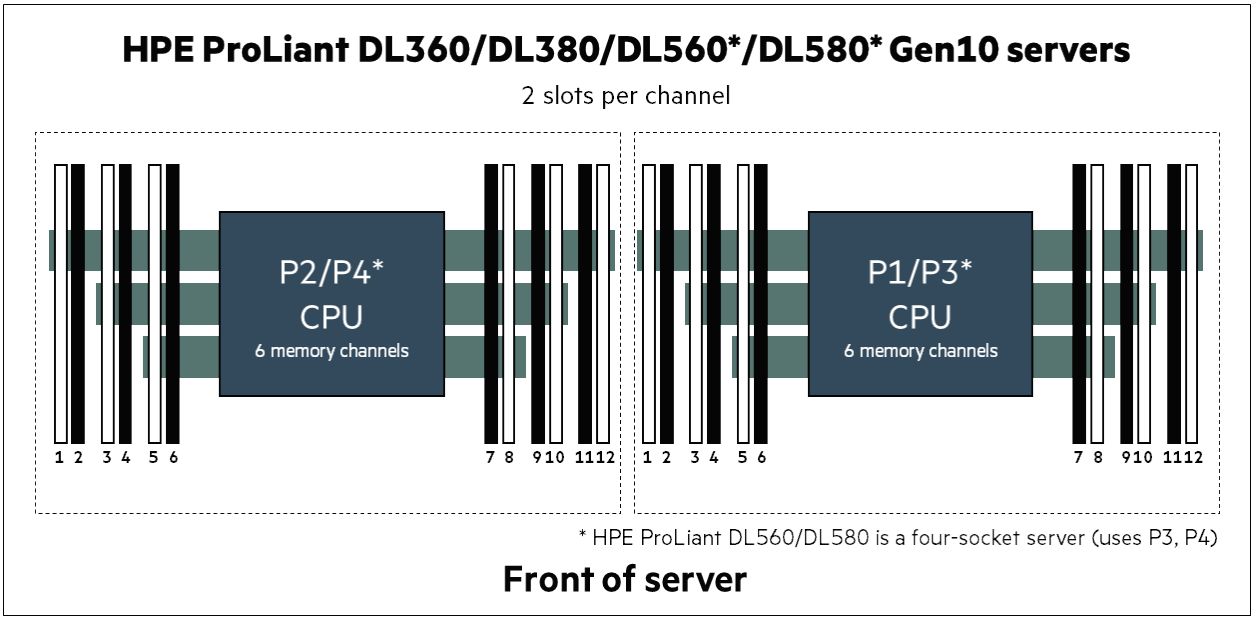


Figure 1. 24 DIMM slot locations in HPE ProLiant DL380 Gen10 servers

Figure 2 shows the DIMM slot configuration in HPE ProLiant BL460c Gen10 server blades, which have two sockets and 16 DIMM slots. The configuration is similar to the HPE ProLiant DL380 Gen10 server, with the main difference being the number of slots on each memory channel. In these servers, one channel on each side of the CPU has two slots attached, while the remaining channels on each side of the CPU have only one slot attached. In the rest of this white paper, this will be referenced as a **2+1+1** configuration. You should populate the memory for these servers following the illustrations found in Appendix B.

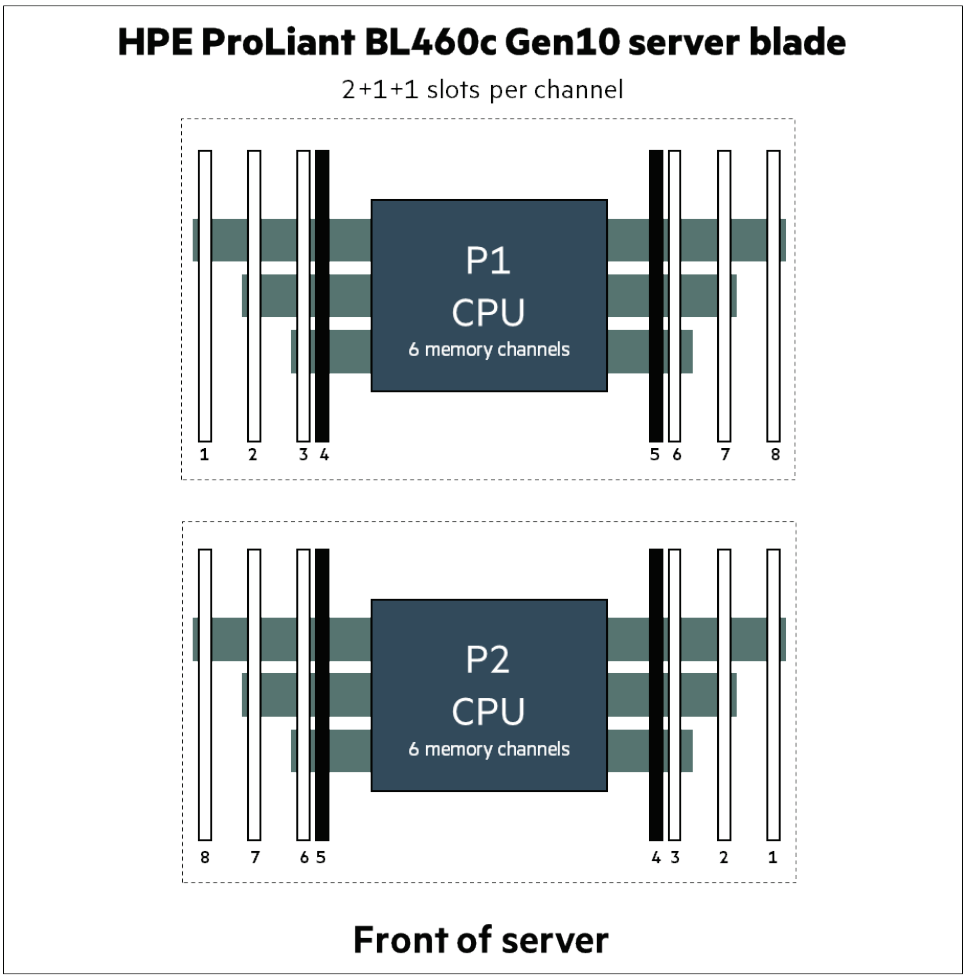


Figure 2. 16 DIMM slot locations in HPE ProLiant BL460c Gen10 two-socket server blades

Population guidelines for HPE SmartMemory DIMMs

This section provides generic guidelines for populating HPE SmartMemory DIMMs in HPE Gen10 servers. See Appendix B for population guidelines for specific HPE Gen10 servers.

HPE SmartMemory DIMMs and HPE NVDIMM-Ns may be populated in many permutations that are allowed but not recommended. The system ROM reports an error during the power on self-test if the population is not supported or not recommended.

Figure 3 shows the population guidelines for HPE SmartMemory DIMMs in HPE Gen10 servers with twelve DIMM slots per CPU (e.g., HPE ProLiant DL360, DL380, DL560, DL580, and ML350 Gen10 servers and HPE Synergy 480 and 660 Gen10 compute modules). For a given number of HPE SmartMemory DIMMs per CPU, populate those DIMMs in the corresponding numbered DIMM slot(s) on the corresponding row.

HPE ProLiant Gen10 12 slot per CPU DIMM population order												
1 DIMM								8				
2 DIMMs								8		10		
3 DIMMs								8		10		12
4 DIMMs			3		5			8		10		
5 DIMMs*			3		5			8		10		12
6 DIMMs	1		3		5			8		10		12
7 DIMMs*	1		3		5		7	8		10		12
8 DIMMs			3	4	5	6	7	8	9	10		
9 DIMMs*	1		3		5		7	8	9	10	11	12
10 DIMMs*	1		3	4	5	6	7	8	9	10		12
11 DIMMs*	1		3	4	5	6	7	8	9	10	11	12
12 DIMMs	1	2	3	4	5	6	7	8	9	10	11	12

* Unbalanced, not recommended

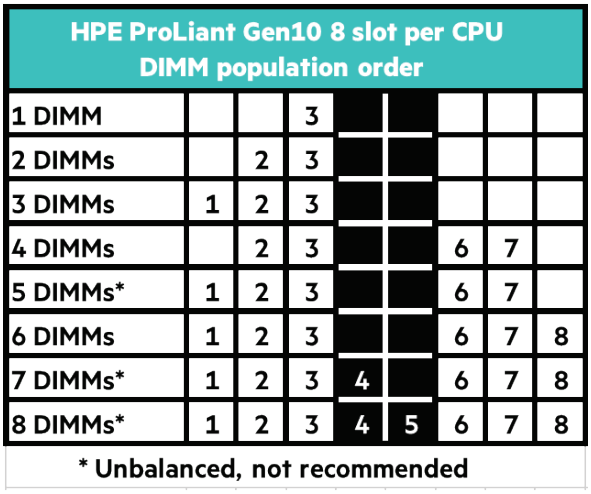
Figure 3. HPE SmartMemory DIMM population guidelines for HPE Gen10 servers with twelve DIMM slots per CPU

As shown in Figure 3, memory should be installed as indicated based upon the total number of DIMMs being installed per CPU. For example, if two HPE SmartMemory DIMMs are being installed per CPU, they should be installed in DIMM slots 8 and 10.

- If six HPE SmartMemory DIMMs are being installed per CPU, they should be installed in DIMM slots 1, 3, 5, 8, 10, and 12.

Unbalanced configurations are noted with an asterisk and are not recommended because memory performance will be inconsistent and degraded compared to balanced configurations. Although the eight DIMM configuration is balanced, it provides 33% less bandwidth than the six DIMM configuration because it does not use all channels.

Figure 4 shows the population guidelines for HPE SmartMemory DIMMs in HPE Gen10 servers with eight DIMM slots per CPU (e.g., HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 servers).



HPE ProLiant Gen10 8 slot per CPU DIMM population order								
1 DIMM			3					
2 DIMMs		2	3					
3 DIMMs	1	2	3					
4 DIMMs		2	3			6	7	
5 DIMMs*	1	2	3			6	7	
6 DIMMs	1	2	3			6	7	8
7 DIMMs*	1	2	3	4		6	7	8
8 DIMMs*	1	2	3	4	5	6	7	8

* Unbalanced, not recommended

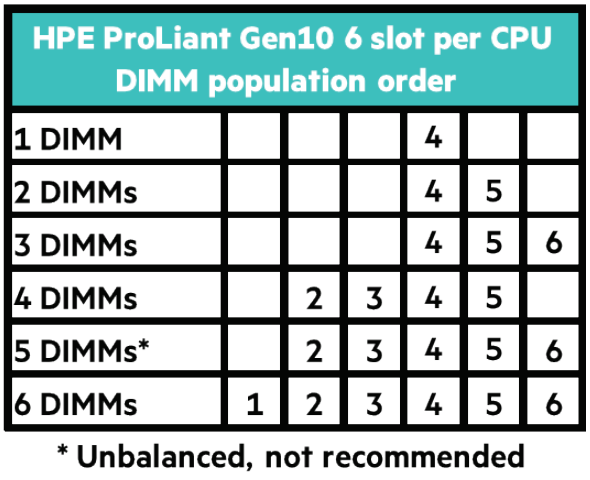
Figure 4. HPE SmartMemory DIMM population guidelines for HPE Gen10 servers with eight DIMM slots per CPU

As shown in Figure 4, memory should be installed as indicated based upon the total number of DIMMs being installed per CPU. For example, if two HPE SmartMemory DIMMs are being installed, they should be installed in DIMM slots 2 and 3.

- If six HPE SmartMemory DIMMs are being installed, they should be installed in DIMM slots 1, 2, 3, 6, 7, and 8.

Unbalanced configurations are noted with an asterisk and are not recommended because memory performance will be inconsistent and degraded compared to balanced configurations.

Figure 5 shows the population guidelines for HPE SmartMemory DIMMs in HPE Gen10 servers with six DIMM slots per CPU (e.g., HPE ProLiant ML110 Gen10 servers).



HPE ProLiant Gen10 6 slot per CPU DIMM population order						
1 DIMM				4		
2 DIMMs				4	5	
3 DIMMs				4	5	6
4 DIMMs		2	3	4	5	
5 DIMMs*		2	3	4	5	6
6 DIMMs	1	2	3	4	5	6

* Unbalanced, not recommended

Figure 5. HPE SmartMemory DIMM population guidelines for HPE Gen10 servers with six DIMM slots per CPU

As shown in Figure 5, memory should be installed as indicated based upon the total number of DIMMs being installed per CPU. For example, if two HPE SmartMemory DIMMs are being installed, they should be installed in DIMM slots 4 and 5.

- If four HPE SmartMemory DIMMs are being installed, they should be installed in DIMM slots 2, 3, 4, and 5.

Unbalanced configurations are noted with an asterisk and are not recommended because memory performance will be inconsistent or degraded compared to a balanced configuration.

Population guidelines for HPE NVDIMM-Ns

This section provides generic guidelines for populating HPE NVDIMM-Ns in HPE Gen10 servers. See Appendix C for population guidelines for specific HPE Gen10 servers.

HPE SmartMemory DIMMs and HPE NVDIMM-Ns may be populated in many permutations that are allowed but not recommended. The system ROM reports an error during the power on self-test if the population is not supported or not recommended.

Populate HPE SmartMemory DIMMs first, then add HPE NVDIMM-Ns in the remaining DIMM slots. Population rules specific to HPE NVDIMM-Ns include:

- The HPE NVDIMM-N population may be different on every processor (this is not recommended for HPE SmartMemory DIMMs).
- If a channel has both an HPE SmartMemory DIMM and an HPE NVDIMM-N, the HPE SmartMemory DIMM must be in the white slot and the HPE NVDIMM-N must be in the black slot.
- Since the HPE 16 GiB NVDIMM-N is a RDIMM, it must be mixed only with HPE SmartMemory RDIMMs and must not be mixed with HPE SmartMemory LRDIMMs.
- HPE NVDIMM-N presence disables RAS features like Online Spare, Mirrored Memory, and HPE Fast Fault Tolerance.

Memory interleaving

Memory interleaving is a technique used to maximize memory performance by spreading memory addresses evenly across memory devices. Interleaved memory results a contiguous memory region across multiple devices with sequential accesses using each memory device in turn, instead of using the same one repeatedly. 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.

Memory interleaving techniques include:

Rank interleaving

This technique interleaves across ranks within a memory channel. When configured correctly, sequential reads within the channel will be interleaved across ranks. This enhances channel throughput by increasing utilization on the channel. Rank interleaving is a lower priority than channel interleaving when creating an interleave region and a 1-DPC region across three channels will be higher priority than a two-DIMM region within a channel.

Channel interleaving

This technique interleaves across memory channels. When configured correctly, sequential reads will be interleaved across memory channels. Channel bandwidth will be accumulated across the interleaved channels. The Unified Extensible Firmware Interface System utilities user guide for HPE ProLiant Gen10 servers and HPE Synergy servers goes into detail regarding setting up memory for interleaving.

Memory controller interleaving

Intel Xeon Scalable processors have two memory controllers per CPU, and the channels selected for channel interleaving are based on matching channels in the memory controllers.

Node interleaving

This technique interleaves across sockets and is not recommended for modern software and operating systems that understand NUMA (non-uniform memory access) system architectures. Node interleaving is not supported while HPE NVDIMM-Ns are present.

Disabling memory interleaving

This option is available from the Advanced Power Management menu in the RBSU Advanced Options menu. Disabling memory interleaving not only saves some power per DIMM but also decreases overall memory system performance.

Understanding balanced DIMM configurations

Optimal memory performance is achieved when the system is configured with a fully homogeneous and balanced DIMM configuration. Unbalanced DIMM configurations are those in which the installed memory is not distributed evenly across the memory channels. Hewlett Packard Enterprise discourages unbalanced configurations because they will always have lower performance than similar balanced configurations. There are two types of unbalanced configurations, each with its own performance implications.

- Unbalanced across channels within a CPU: The memory installed on each populated channel is not identical. This is undesirable for:
  - HPE SmartMemory DIMMs
  - HPE NVDIMM-Ns with interleaving enabled
- But is acceptable for HPE NVDIMM-Ns with interleaving disabled.
- Unbalanced across processors: A different amount of memory is installed on each of the processors. This is usually undesirable for HPE SmartMemory DIMMs, but is often acceptable for HPE NVDIMM-Ns.

Memory configurations that are unbalanced across channels

In unbalanced memory configurations across channels, the memory controller will split memory into regions, as shown in Figure 6. In a balanced configuration, there will be one region that includes all installed DIMMs. If the memory configuration is unbalanced, it will attempt to create multiple balanced regions. First, it will create the largest possible balanced region with the installed memory. The next largest region comes next, and so on. In this manner, the memory controller will create regions until all installed memory has been assigned to a region. The performance of these regions differs, resulting in erratic performance.

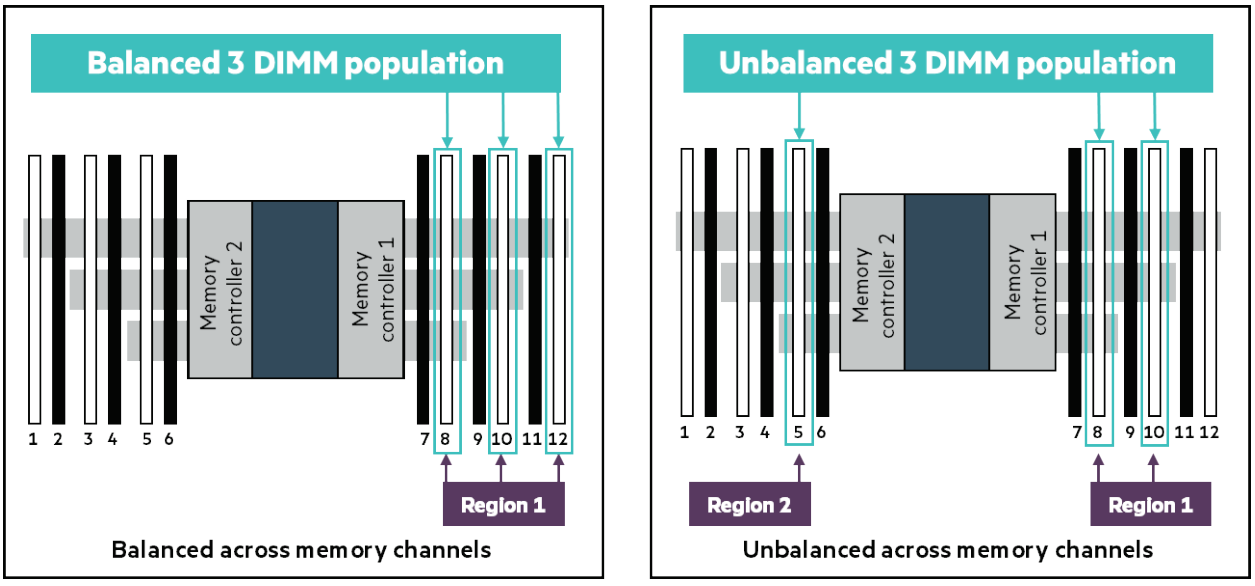


Figure 6. Examples of balanced and unbalanced configurations

In Figure 6, the illustration on the left depicts a balanced configuration, since each of the populated memory channel contains the same number of DIMMs (one each). Conversely, the image on the right is unbalanced because the DIMM in DIMM slot 5 creates a second memory region.

The primary effect of memory configurations that are unbalanced across channels is a decrease in memory throughput in those regions that span fewer memory channels. In the unbalanced example in Figure 6, worst case measured memory throughput in Region 2 would be 33% or less than the throughput in the balanced example. Even in Region 1 in the unbalanced picture, throughput would be limited to no more than 66% of what the single region in the balanced example could provide.

Memory configurations that are unbalanced across processors

Figure 7 shows a memory configuration that is unbalanced across processors. The CPU 1 threads operating on the larger memory capacity of CPU 1 may have adequate local memory with relatively low latencies and high throughput. The CPU 2 threads operating on the smaller memory capacity of CPU 2 may consume all available memory on CPU 2 and request remote memory from CPU 1. The longer latencies and limited throughput of cross-CPU communications associated with the remote memory will result in reduced performance of those threads. In practice, this may result in non-uniform performance characteristics for software program threads, depending on which processor executes them.

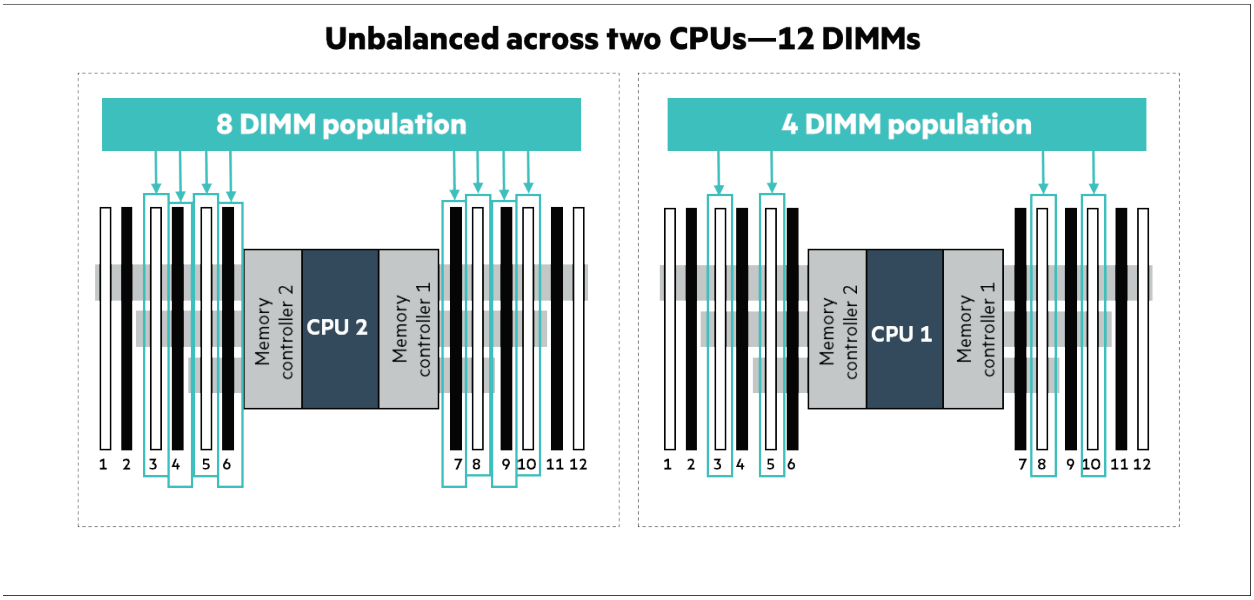


Figure 7. Example of memory that is unbalanced across processors

Figure 7 shows an example of unbalanced memory configurations across processors. In this example, the first processor contains four DIMMs while the second CPU has eight DIMMs installed.

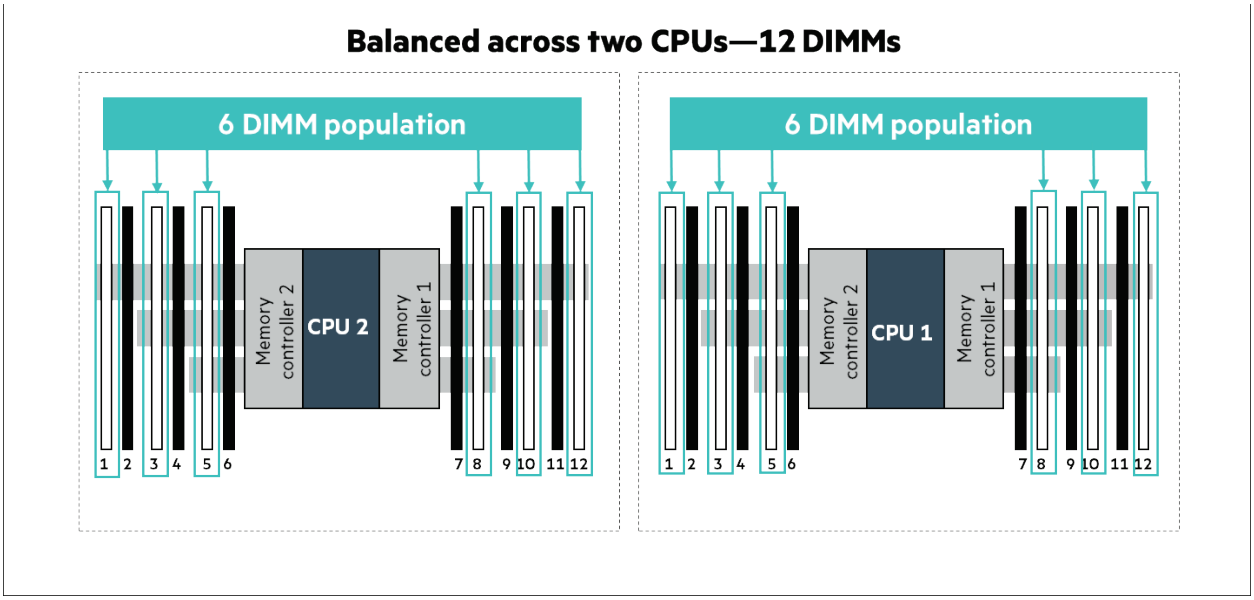


Figure 8. Example of a memory configuration that is balanced across processors

Figure 8 shows an example of a configuration that is balanced across processors. In this example, both processors have six DIMMs installed.

Memory RAS mode and population requirements

HPE Gen10 servers using Intel Xeon Scalable processors support four different memory RAS (reliability, accessibility, and serviceability) modes. If you plan to enable any of these advanced RAS modes, please see the HPE Server Memory RAS white paper for more specific information regarding memory configuration and population rules. The RAS modes supported include:

- Advanced error correction code
- Online spare
- Mirrored memory
- HPE Fast Fault Tolerance

The rules on channel DIMM population and channel DIMM matching vary by the RAS mode used. However, regardless of RAS mode, the requirements for DIMM population within a system and a channel must be met at all times.

For RAS modes that require matching DIMM populations, the same DIMM slot positions across channels must hold the same DIMM type with regard to size and organization. DIMM timings do not have to match, but timings will be set to support all DIMMs populated (that is, DIMMs with slower timings will force faster DIMMs to the slower common timing modes).

Conclusion

Following the population guidelines maximizes memory performance of HPE SmartMemory DIMMs and HPE NVDIMM-Ns in HPE Gen10 servers with Intel Xeon Scalable processors.

Appendix A—HPE Gen10 DIMM slot locations

This section illustrates the physical location of the DIMM slots for HPE Gen10 servers using Intel Xeon Scalable processors.

HPE servers support twelve, eight, or six DIMM slots per CPU.

DIMM slot locations in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers

HPE ProLiant DL360, DL380, DL560, and DL580 Gen10 servers have twelve DIMM slots per CPU.

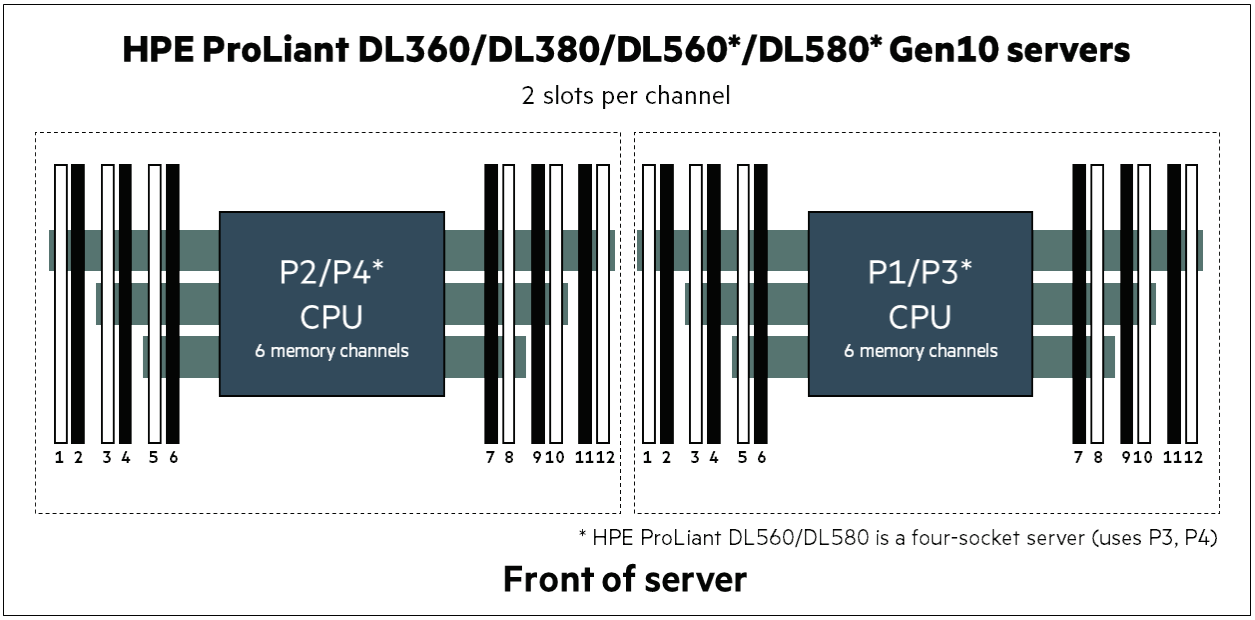


Figure 9. DIMM slot locations in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers

DIMM slot locations in HPE ProLiant ML350 Gen10 servers

HPE ProLiant ML350 Gen10 servers have twelve DIMM slots per CPU.

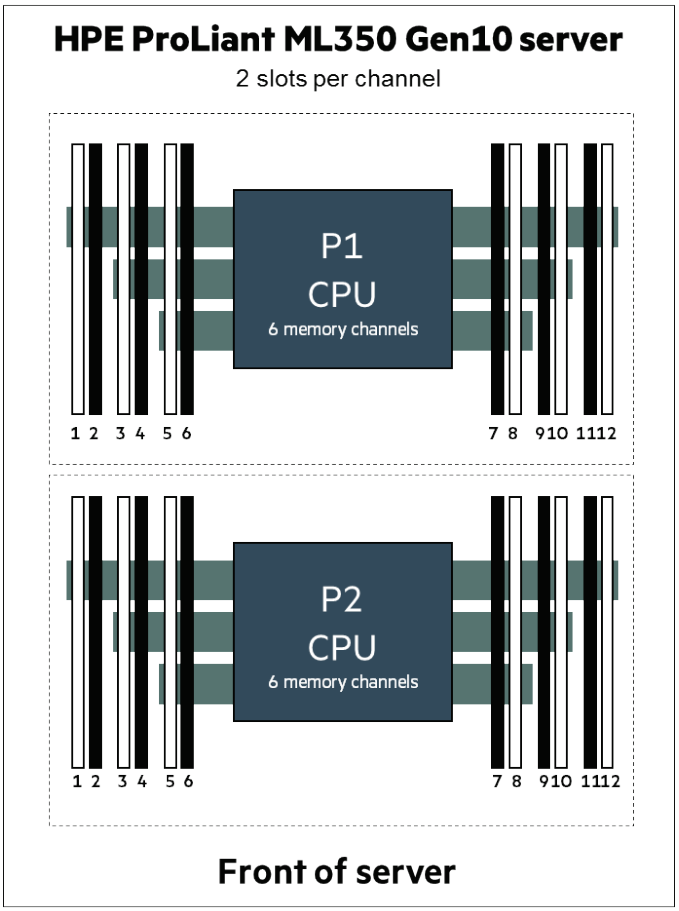


Figure 10. DIMM slot locations in HPE ProLiant ML350 Gen10 servers

DIMM slot locations in HPE Synergy 480 Gen10 compute modules

HPE Synergy 480 Gen10 compute modules have twelve DIMM slots per CPU.

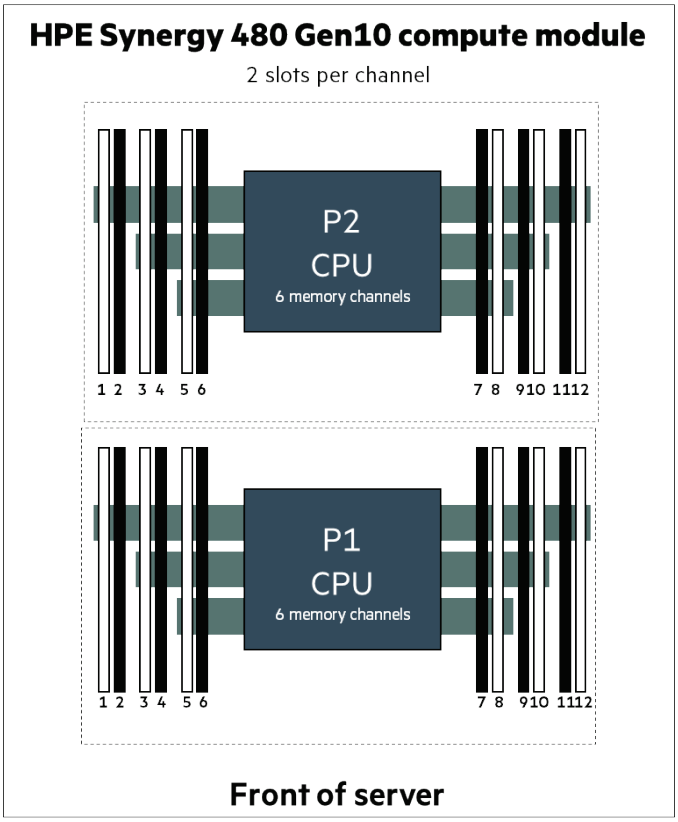


Figure 11. DIMM slot locations for HPE Synergy 480 Gen10 compute modules

DIMM slot locations in HPE Synergy 660 Gen10 compute modules

HPE Synergy 660 Gen10 compute modules have twelve DIMM slots per CPU.

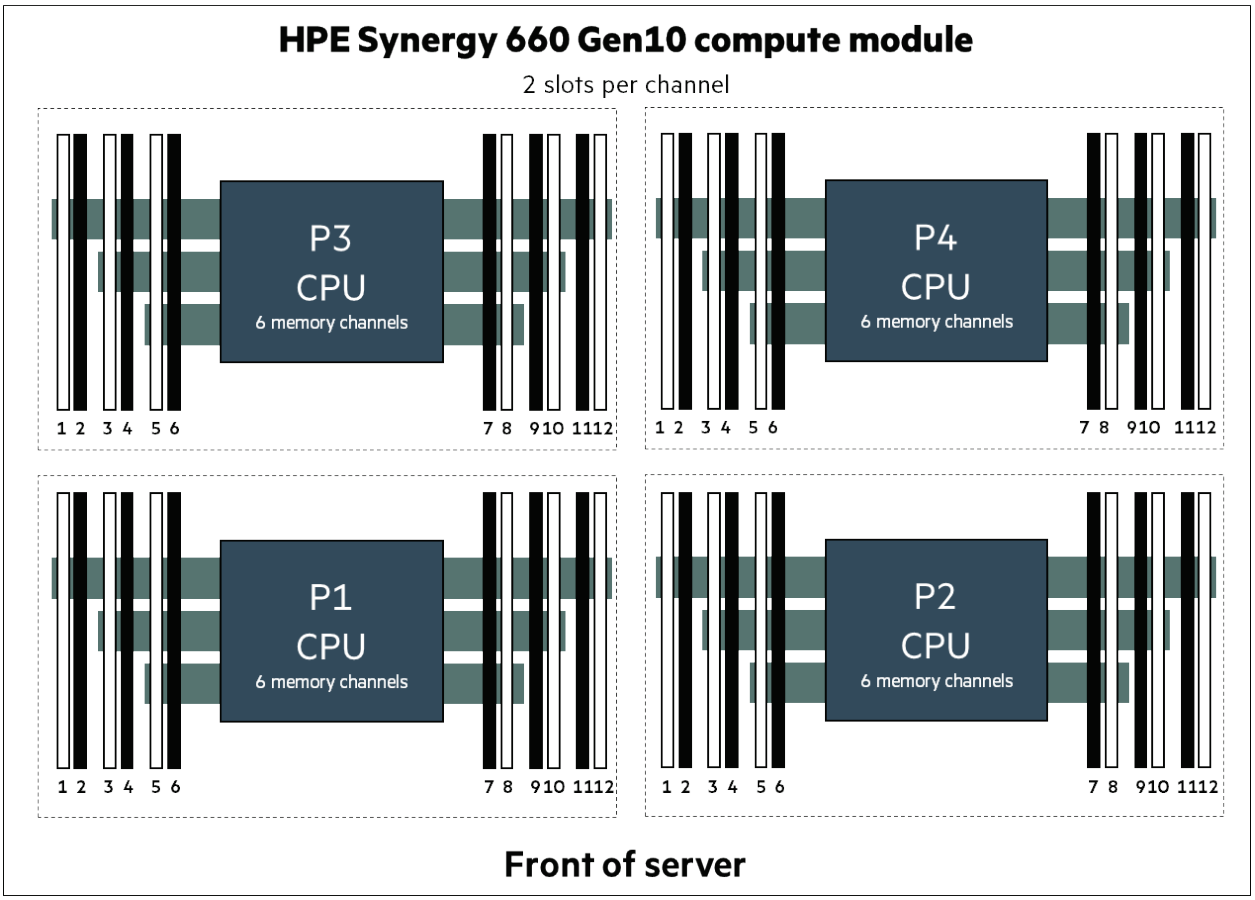


Figure 12. DIMM slot locations for HPE Synergy 660 Gen10 compute modules

DIMM slot locations in HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 servers

HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 servers have eight DIMM slots per CPU. Six channels have one DIMM slot, and two channels have two DIMM slots.

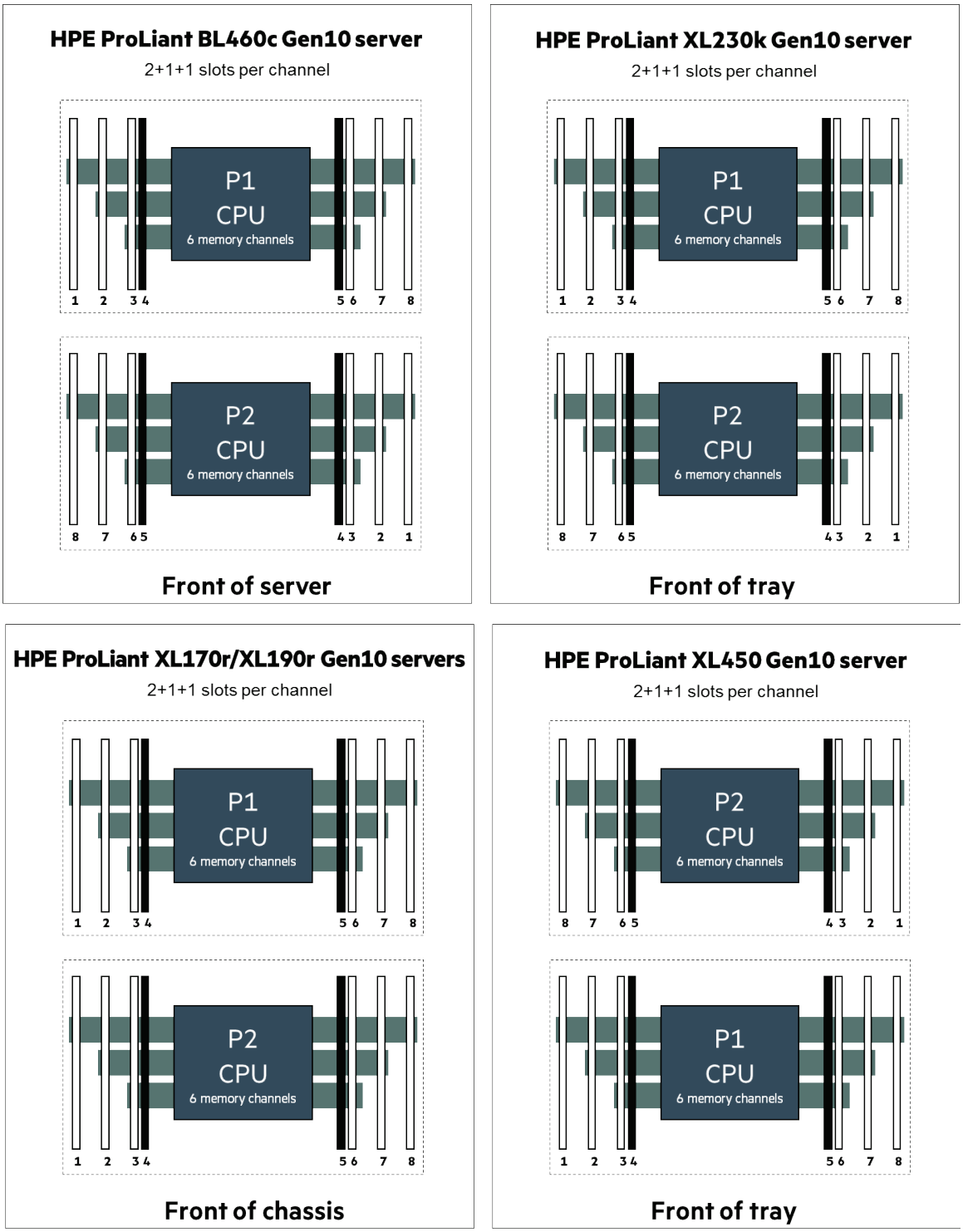


Figure 13. DIMM slot locations in HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 servers

DIMM slot locations in HPE ProLiant ML110 Gen10 servers

HPE ProLiant ML110 Gen10 servers have six DIMM slots per CPU.

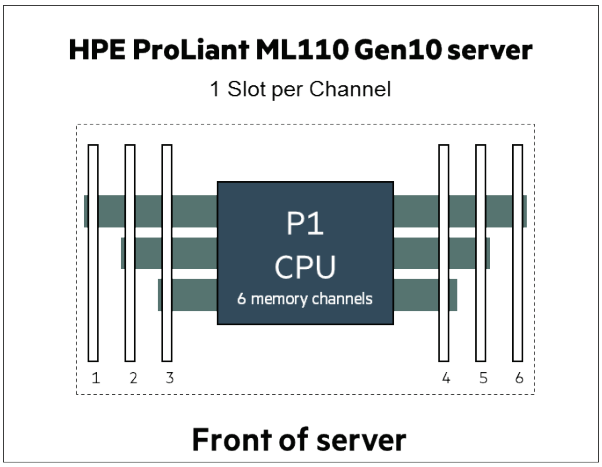


Figure 14. DIMM slot locations in HPE ProLiant ML110 Gen10 servers

Appendix B—Population guidelines for HPE SmartMemory DIMMs

This section illustrates which DIMM slots to use when populating memory in HPE Gen10 servers using Intel Xeon Scalable processors. Each illustration reflects the DIMM slots to use for a given number of DIMMs around a single processor, given a common DIMM type. If multiple processors are installed, split the DIMMs evenly across the processors and follow the corresponding rule when populating DIMMs for each processor. Figures 15 to 21 represent the bootstrap processor and the population shown will ensure that the first DIMM populated is in the right place. Unbalanced configurations are noted with an asterisk and are not recommended because memory performance will be inconsistent or degraded compared to a balanced configuration.

In cases of a heterogeneous mix, take each DIMM type and create a configuration as if it were a homogeneous configuration. Depending on the per-channel rules, populate the DIMMs with highest rank count in white DIMM slots in each channel, then populate the other DIMMs in the black DIMM slots in each channel. See the last illustration for an example of a popular mix.

Population guidelines for HPE SmartMemory DIMMs in HPE ProLiant DL360/DL380/DL560/DL580/ML350 Gen10 servers

HPE ProLiant DL360, DL380, DL560, DL580, and ML350 Gen10 servers have twelve DIMM slots per CPU.

DIMM Population Order for CPU												
1 DIMM								8				
2 DIMMs								8		10		
3 DIMMs								8		10		12
4 DIMMs			3		5			8		10		
5 DIMMs			3		5			8		10		12
6 DIMMs	1		3		5			8		10		12
7 DIMMs	1		3		5		7	8		10		12
8 DIMMs			3	4	5	6	7	8	9	10		
9 DIMMs	1		3		5		7	8	9	10	11	12
10 DIMMs	1		3	4	5	6	7	8	9	10		12
11 DIMMs	1		3	4	5	6	7	8	9	10	11	12
12 DIMMs	1	2	3	4	5	6	7	8	9	10	11	12

Figure 15. Population guidelines for HPE SmartMemory DIMMs in HPE ProLiant DL360/DL380/DL560/DL580/ML350 Gen10 servers

Population guidelines for HPE SmartMemory DIMMs in HPE Synergy 480 Gen10 compute modules

HPE Synergy 480 Gen10 compute modules have twelve DIMM slots per CPU.

DIMM Population Order for CPU1												
1 DIMM								8				
2 DIMMs								8		10		
3 DIMMs								8		10		12
4 DIMMs			3		5			8		10		
5 DIMMs			3		5			8		10		12
6 DIMMs	1		3		5			8		10		12
7 DIMMs	1		3		5		7	8		10		12
8 DIMMs			3	4	5	6	7	8	9	10		
9 DIMMs	1		3		5		7	8	9	10	11	12
10 DIMMs	1		3	4	5	6	7	8	9	10		12
11 DIMMs	1		3	4	5	6	7	8	9	10	11	12
12 DIMMs	1	2	3	4	5	6	7	8	9	10	11	12

DIMM Population Order for CPU2												
1 DIMM					5							
2 DIMMs			3		5							
3 DIMMs	1		3		5							
4 DIMMs			3		5			8		10		
5 DIMMs	1		3		5			8		10		
6 DIMMs	1		3		5			8		10		12
7 DIMMs	1		3		5	6		8		10		12
8 DIMMs			3	4	5	6	7	8	9	10		
9 DIMMs	1	2	3	4	5	6		8		10		12
10 DIMMs	1		3	4	5	6	7	8	9	10		12
11 DIMMs	1	2	3	4	5	6	7	8	9	10		12
12 DIMMs	1	2	3	4	5	6	7	8	9	10	11	12

Figure 16. Population guidelines for HPE SmartMemory DIMMs in HPE Synergy 480 Gen10 compute modules

Population guidelines for HPE SmartMemory DIMMs in HPE Synergy 660 Gen10 compute modules

HPE Synergy 660 Gen10 compute modules have twelve DIMM slots per CPU.

DIMM Population Order for CPU 1/2												
1 DIMM								8				
2 DIMMs								8		10		
3 DIMMs								8		10		12
4 DIMMs			3		5			8		10		
5 DIMMs			3		5			8		10		12
6 DIMMs	1		3		5			8		10		12
7 DIMMs	1		3		5		7	8		10		12
8 DIMMs			3	4	5	6	7	8	9	10		
9 DIMMs	1		3		5		7	8	9	10	11	12
10 DIMMs	1		3	4	5	6	7	8	9	10		12
11 DIMMs	1		3	4	5	6	7	8	9	10	11	12
12 DIMMs	1	2	3	4	5	6	7	8	9	10	11	12

DIMM Population Order for CPU 3/4												
1 DIMM					5							
2 DIMMs			3		5							
3 DIMMs	1		3		5							
4 DIMMs			3		5			8		10		
5 DIMMs	1		3		5			8		10		
6 DIMMs	1		3		5			8		10		12
7 DIMMs	1		3		5	6		8		10		12
8 DIMMs			3	4	5	6	7	8	9	10		
9 DIMMs	1	2	3	4	5	6		8		10		12
10 DIMMs	1		3	4	5	6	7	8	9	10		12
11 DIMMs	1	2	3	4	5	6	7	8	9	10		12
12 DIMMs	1	2	3	4	5	6	7	8	9	10	11	12

Figure 17. Population guidelines for HPE SmartMemory DIMMs in HPE Synergy 660 Gen10 compute modules

Population guidelines for HPE SmartMemory DIMMs in HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 servers

HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 server have eight DIMM slots per CPU.

On these platforms, for maximum throughput, the recommended configuration is six DIMMs per CPU. Eight DIMMs per CPU while maximizing memory capacity results in an unbalanced configuration, which will reduce performance.

DIMM Population Order per CPU								
1 DIMM			3					
2 DIMMs		2	3					
3 DIMMs	1	2	3					
4 DIMMs		2	3			6	7	
5 DIMMs	1	2	3			6	7	
6 DIMMs	1	2	3			6	7	8
7 DIMMs	1	2	3	4		6	7	8
8 DIMMs	1	2	3	4	5	6	7	8

Figure 18. Population guidelines for HPE SmartMemory DIMMs in HPE ProLiant BL460c Gen10 server blades and HPE ProLiant XL170r/XL190r/XL230k/XL450 Gen10 servers

Population guidelines for HPE SmartMemory DIMMs in HPE ProLiant ML110 Gen10 servers

HPE ProLiant ML110 Gen10 servers have six DIMM slots per CPU.

DIMM Population Order per CPU						
1 DIMM				4		
2 DIMMs				4	5	
3 DIMMs				4	5	6
4 DIMMs		2	3	4	5	
5 DIMMs		2	3	4	5	6
6 DIMMs	1	2	3	4	5	6

Figure 19. Population guidelines for HPE SmartMemory DIMMs in HPE ProLiant ML110 Gen10 servers

Mixed HPE SmartMemory DIMM configurations

In cases of a heterogeneous mix, take each DIMM type and create a configuration as if it were a homogeneous configuration. Depending on the per-channel rules, populate the DIMMs with highest rank count in white DIMM slots in each channel, then populate the other DIMMs in the black DIMM slots in each channel as shown in the following illustration.

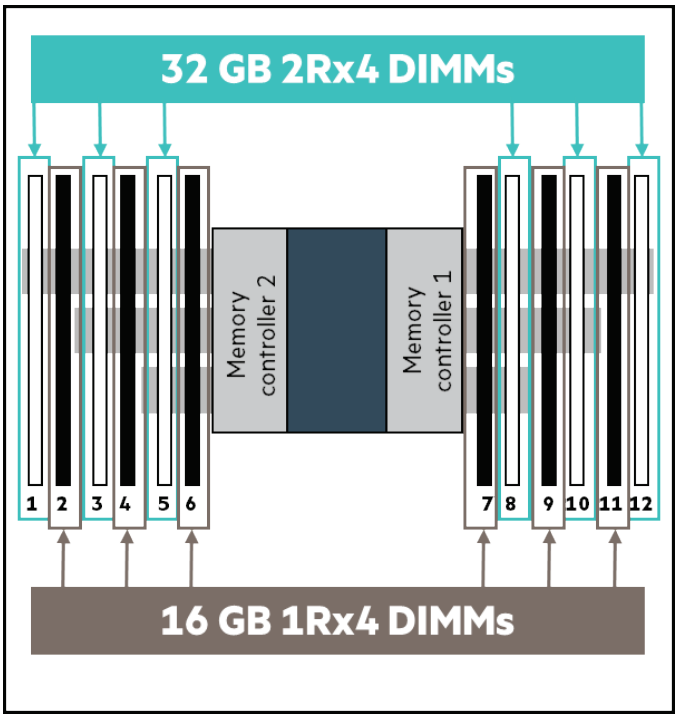


Figure 20. Mixing HPE SmartMemory 32 GB and 16 GB DIMMs

Appendix C—Population guidelines for HPE NVDIMM-Ns

HPE NVDIMM-Ns may be included alongside HPE SmartMemory DIMMs in select HPE Gen10 servers.

Population guidelines for HPE NVDIMM-Ns in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers

Since HPE NVDIMM-Ns are designed to unleash maximum system performance, systems using HPE NVDIMM-Ns should have one HPE SmartMemory DIMM per channel to provide maximum memory performance (i.e., six HPE SmartMemory DIMMs per processor). One to six HPE NVDIMM-Ns (based on persistent memory capacity and performance needs) should then be added as follows:

Table 2. Population guidelines for HPE NVDIMM-Ns with six HPE SmartMemory DIMMs in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers

	Memory Controller:	**Memory Controller 2**						**Memory Controller 1**							
	Memory Channel:	**Channel 6**		**Channel 5**		**Channel 4**		**Channel 1**		**Channel 2**		**Channel 3**			
HPE NVDIMM-N count	**DIMM slot number:**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Persistent memory capacity[1]**	**Nominal bandwidth[2]**
1		R	N	R		R			R		R		R	16 GiB	21.33 GB/s
2		R	N	R	N	R			R		R		R	32 GiB	42.67 GB/s
3		R	N	R	N	R	N		R		R		R	48 GiB	64 GB/s
4		R	N	R	N	R			R	N	R	N	R	64 GiB	85.33 GB/s
5[3]		R	N	R	N	R	N		R	N	R	N	R	80 GiB	Inconsistent
6		R	N	R	N	R	N	N	R	N	R	N	R	96 GiB	128 GB/s

Key: R=Regular DIMM (i.e., an HPE SmartMemory DIMM), N=HPE NVDIMM-N.

[1] Persistent Memory capacity assumes that 16 GiB NVDIMM-Ns are used.
[2] Nominal bandwidth assumes that the system is running at 2667 MT/s and NVDIMM-N interleaving is enabled.
[3] NVDIMM-N interleaving should be disabled if five NVDIMM-Ns are used.

Population guidelines for HPE NVDIMM-Ns in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers

Although Hewlett Packard Enterprise recommends that HPE NVDIMM-Ns be used with six HPE SmartMemory DIMMs, they may also be combined with smaller quantities of HPE SmartMemory DIMMs if regular memory performance is not so important or if larger persistent memory capacity is needed.

The recommended configurations below assume that all HPE SmartMemory DIMMs are identical (no mix of ranks):

Table 3. Extended population guidelines for HPE NVDIMM-Ns in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers (part 1)

	Memory Controller:	**Memory Controller 2**							**Memory Controller 1**					
	Memory Channel:	**Channel 6**		**Channel 5**		**Channel 4**			**Channel 1**		**Channel 2**		**Channel 3**	
Regular DIMM + HPE NVDIMM-N count	**DIMM slot number:**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Persistent memory capacity[4]**
1+1		N							R					16 GiB
1+2		N		N					R					32 GiB
1+3		N		N		N			R					48 GiB
1+4		N		N					R		N		N	64 GiB
1+5[5]		N		N		N			R		N		N	80 GiB
1+6		N		N		N		N	R		N		N	96 GiB
1+7[5]		N	N	N	N	N			R		N		N	112 GiB
1+8[5]		N	N	N	N	N	N		R		N		N	128 GiB
1+9[5]		N	N	N	N	N	N		R		N	N	N	144 GiB
1+10[5]		N	N	N	N	N	N		R	N	N	N	N	160 GiB
1+11[5]		N	N	N	N	N	N	N	R	N	N	N	N	176 GiB
2+1		N							R		R			16 GiB
2+2		N		N					R		R			32 GiB
2+3		N		N		N			R		R			48 GiB
2+4[6]		N		N					R	N	R		N	64 GiB
2+4[5]		N		N		N			R		R		N	64 GiB
2+5[5]		N	N	N		N			R		R		N	80 GiB
2+6[6]		N		N		N		N	R	N	R		N	96 GiB
2+6[5]		N	N	N	N	N	N		R		R			96 GiB
2+7[5]		N	N	N	N	N	N		R		R		N	112 GiB
2+8[5]		N	N	N	N	N	N		R		R	N	N	128 GiB
2+9[5]		N	N	N	N	N	N		R	N	R	N	N	144 GiB
2+10[5]		N	N	N	N	N	N	N	R	N	R	N	N	160 GiB

Key: R=Regular DIMM (i.e., an HPE SmartMemory DIMM), N=HPE NVDIMM-N.

[4] Persistent Memory capacity assumes that 16 GiB NVDIMM-Ns are used.
[5] NVDIMM-N interleaving should be disabled for this configuration.
[6] NVDIMM-N interleaving should be enabled for this configuration.

Table 4. Extended population guidelines for HPE NVDIMM-Ns in HPE ProLiant DL360/DL380/DL560/DL580 Gen10 servers (part 2)

	Memory Controller:	Memory Controller 2							Memory Controller 1						
	Memory Channel:	Channel 6		Channel 5		Channel 4			Channel 1		Channel 2		Channel 3		
Regular DIMM + HPE NVDIMM-N count	DIMM slot number:	1	2	3	4	5	6	7	8	9	10	11	12	Persistent memory capacity[7]
3+1		N							R		R		R	16 GiB
3+2		N		N					R		R		R	32 GiB
3+3		N		N		N			R		R		R	48 GiB
3+4[8]		N		N					R	N	R	N	R	64 GiB
3+4[9]		N	N	N		N			R		R		R	64 GiB
3+5[9]		N	N	N	N	N			R		R		R	80 GiB
3+6		N		N		N		N	R	N	R	N	R	96 GiB
3+7[9]		N	N	N	N	N	N		R		R	N	R	112 GiB
3+8[9]		N	N	N	N	N	N		R	N	R	N	R	128 GiB
3+9[9]		N	N	N	N	N	N	N	R	N	R	N	R	144 GiB
4+1		N		R		R			R		R			16 GiB
4+2		N		R		R			R		R		N	32 GiB
4+3[8]		N		R	N	R	N		R		R			48 GiB
4+3[9]		N	N	R		R			R		R		N	48 GiB
4+4[8]		N		R	N	R			R	N	R		N	64 GiB
4+4[9]		N	N	R		R			R		R	N	N	64 GiB
4+5[9]		N	N	R	N	R			R		R	N	N	80 GiB
4+6[8]		N		R	N	R	N	N	R	N	R		N	96 GiB
4+6[9]		N	N	R	N	R	N		R		R	N	N	96 GiB
4+7[9]		N	N	R	N	R	N		R	N	R	N	N	112 GiB
4+8[9]		N	N	R	N	R	N	N	R	N	R	N	N	128 GiB
6+1		R	N	R		R			R		R		R	16 GiB
6+2		R	N	R	N	R			R		R		R	32 GiB
6+3		R	N	R	N	R	N		R		R		R	48 GiB
6+4		R	N	R	N	R			R	N	R	N	R	64 GiB
6+5[9]		R	N	R	N	R	N		R	N	R	N	R	80 GiB
6+6		R	N	R	N	R	N	N	R	N	R	N	R	96 GiB

Key: R=Regular DIMM (i.e., an HPE SmartMemory DIMM), N=HPE NVDIMM-N.

[7] Persistent Memory capacity assumes that 16 GiB NVDIMM-Ns are used.
[8] NVDIMM-N interleaving should be enabled for this configuration.
[9] NVDIMM-N interleaving should be disabled for this configuration.

Population guidelines for HPE NVDIMM-Ns in HPE ProLiant BL460c Gen10 server blades

In the HPE ProLiant BL460c Gen10 server blade, only some of the DIMM slots are connected to the Smart Storage battery and are suitable for HPE NVDIMM-Ns.

Table 5. Population guidelines for HPE NVDIMM-Ns in HPE BL460c Gen10 server blades

CPU			Smart Storage Battery Support								
			Memory Controller 1				Memory Controller 2				
			Channel 3	Channel 2	Channel 1		Channel 4		Channel 5	Channel 6	
P1	Regular + NVDIMM-N count	Configuration number	1	2	3	4	5	6	7	8	Capacity (using 16 GiB NVDIMM-Ns)
	1+1	1			R					N	16 GiB
	1+2	2			R				N	N	32 GiB
	2+1	3		R	R					N	16 GiB
	2+2	4		R	R				N	N	32 GiB
	3+1	5	R	R	R					N	16 GiB
	3+2	6	R	R	R				N	N	32 GiB
	4+1	7		R	R			R	R	N	16 GiB
	4+2	8		R	R		N	R	R	N	32 GiB
	6+1	9	R	R	R		N	R	R	R	16 GiB

CPU			Smart Storage Battery Support								
			Memory Controller 2				Memory Controller 1				
			Channel 6	Channel 5	Channel 4		Channel 1		Channel 2	Channel 3	
P2	Regular + NVDIMM-N count	Configuration number	8	7	6	5	4	3	2	1	Capacity (using 16 GiB NVDIMM-Ns)
	1+1	1						R		N	16 GiB
	1+2	2						R	N	N	32 GiB
	2+1	3						R	R	N	16 GiB
	2+2	4			R			R	N	N	32 GiB
	3+1	5					N	R	R	R	16 GiB
	3+2	6	R	R	R			N	N		32 GiB
	4+1	7		R	R			R	R	N	16 GiB
	4+2	8		R	R		N	R	R	N	32 GiB
	6+1	9	R	R	R		N	R	R	R	16 GiB

Appendix D—Balanced Population Rules versus RAS Population Rules

Refer to the for the HPE Server Memory RAS white paper when enabling RAS features. Below is an example of a RAS population that differs from the balanced population for performance.

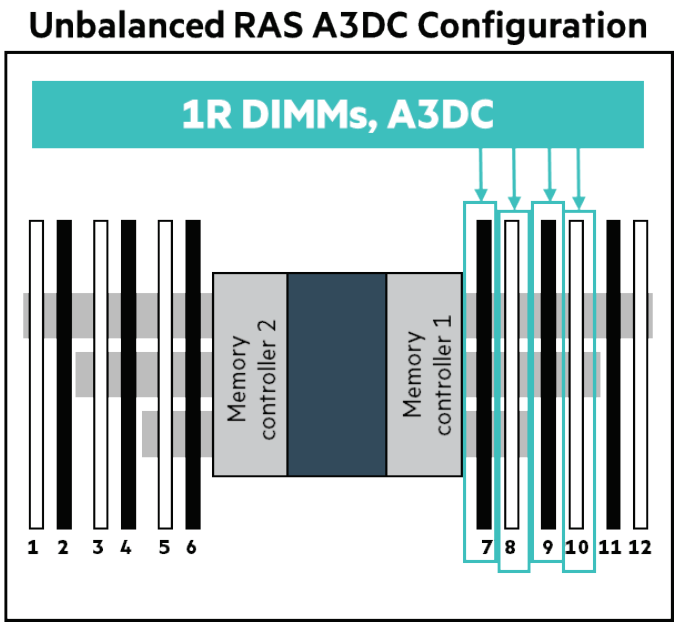


Figure 21. RAS population that differs from balanced population

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