AMD EPYC™ 9004 Series Memory Population Recommendations

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Date	Version	Changes
May, 2023	1.0	Initial public release.
Jun, 2023	1.1	Minor errata corrections globally.

Audience

This guide provides a high-level technical overview of 4th Gen AMD EPYC™ 9004 Series Processor internal IP.

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Note: All of the recommendations described in this User Guide apply to all AMD EPYC 9004 Series Processors of all core counts with or without AMD 3D V-Cache™ except where explicitly noted otherwise.

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Chapter 1

Introduction

The memory subsystem of AMD EPYC processors plays a significant role in overall server performance. Proper configuration maximizes bandwidth and minimizes latency, thereby improving performance. By contrast, improper configuration degrades overall performance by reducing memory bandwidth and/or increasing latency.

Balanced memory configurations are critical to maximizing server memory bandwidth and overall performance. 4th Gen AMD EPYC processors support 12 memory channels. You can choose to populate memory using either:

- One DIMM per channel (1DPC).
- Two DIMMs per channel (2DPC).

This guide presents examples of balanced memory configurations and includes some general recommendations for a variety of workloads.

1.1 Memory Topology

Each 4th Gen AMD EPYC processor (9004 Series) includes 12 Unified Memory Controllers (UMC). Each UMC controls a single memory channel, and each channel can be populated with either 1 or 2 DIMMs, as described above. The tables and images in this User Guide are examples for reference purposes only. Please refer to your system technical specifications for UMC and memory channel mapping.. Table 1-1 lists each UMC and the memory channel associated with that UMC based on the internal AMD Customer Reference Board (CRB) layout; please consult your server vendor for additional information.

Memory Channel Notation	Memory Channel #	UMC #
A	3	3
B	4	4
C	0	0
D	5	5
E	1	1
F	2	2
G	9	9
H	10	10
I	6	6
J	11	11
K	7	7
L	8	8

Table 1-1: Memory channels by AMD EPYC UMC

In Table 1-1:

- **Memory Channel Notation:** This is the notation used in Figures x-x for clarity.
- **Memory Channel #:** Actual number of the memory channel.
- **UMC #:** UMC on the AMD EPYC processor that controls the memory channel.

Figure 1 provides a graphical view of the information contained in Table 1-1 along with the relative distance of each memory channel from the AMD EPYC processor. Figures x-x will use this same view to illustrate the different recommended configurations.

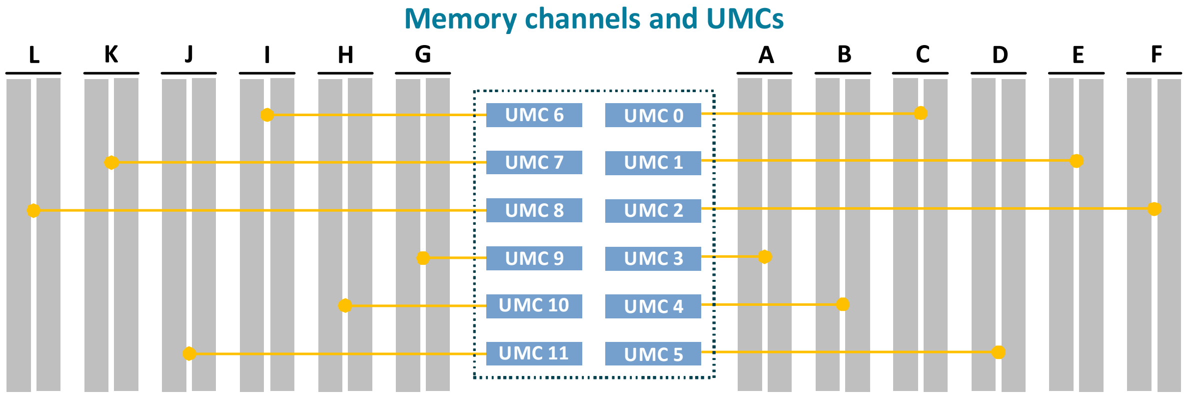

Figure 1-1: Physical DIMM layout with corresponding memory channels and UMCs

As shown in Figure 1-1:

- Channels A and G are the closest memory channels to the AMD EPYC processor.
- Channels L and F are the furthest memory channels from the AMD EPYC processor.

1.2 Memory Interleaving

4th Gen AMD EPYC processors interleave across UMCs and memory controllers. Interleaving boosts memory bandwidth by spreading contiguous memory access across all memory channels in the interleave set as opposed to sending all memory accesses to a single memory channel, thereby allowing the AMD EPYC processor to access multiple memory channels at once. 4th Gen AMD EPYC processors support interleave sets of 2, 4, 6, 8, 10, or 12 memory channels. Interleaving requires all channels to use the same DIMM type, total memory capacity, and ranks. For example, populating four memory channels with the same total memory capacity and number of ranks creates a 4-channel interleave set across those four channels.

4th Gen AMD EPYC processors can also form multiple interleave sets if a particular memory configuration cannot form a single interleave set. In this situation, the memory bandwidth performance depends on the number of DIMMs in each interleave set and the specific memory region being accessed. Contiguous memory accesses to a memory region with more channels in the interleave set will boost performance compared to having fewer channels in the interleave set.

Chapter 2 Memory Configuration Options

This chapter lists the DIMM type supported by 4th Gen AMD EPYC processors, describes balanced vs. imbalanced memory configurations, and depicts the supported 1DPC memory configuration options.

2.1 Memory Characteristics

4th Gen AMD EPYC processors support memory with the following characteristics:

- **RDIMM:**
  - 16GB 1Rx8
  - 24GB 1Rx8
  - 32GB 1Rx4
  - 32GB 2Rx8
  - 40GB 2Rx8
  - 48GB 1Rx4
  - 48GB 2Rx8
  - 64GB 2Rx4
  - 80GB 2Rx4
  - 96GB 2Rx4
- **3DS RDIMM:**
  - 128GB 2S2Rx4
  - 192GB 2S2Rx4
  - 256GB 2S4Rx4
  - 384GB 2S4Rx4
  - 512GB 2S8R (pending ecosystem enablement)
- **ECC:** 80b x4, 80b x8, 72b x4.
- **Optimized Bounded Fault ECC DRAM:** 80b x4 AMDC, 80b x8, 72b x4.

2.2 Unsupported DIMM Types

The following DIMM types are not supported

- LRDIMM
- UDIMM
- NVDIMM-N
- NVDIMM-P

When populating memory on a server powered by one or more 4th AMD EPYC processors:

- All DIMM modules must be RDIMM or RDIMM 3DS module types with the same ECC configuration. Do not mix DIMM module types within a memory channel.
- Do not mix x4 and x8 DIMMs within a memory channel.
- Do not mix 3DS and non-3DS memory modules in a 2DPC system.

Note: Ecosystem memory vendors may not support all of the DIMM and DRAM sizes and configurations listed in this guide.

2.3 Balanced Memory Configurations

Balanced memory configurations maximize memory bandwidth by optimizing memory interleaving. To obtain a balanced memory configuration:

- Populate each socket with 1, 2, 4, 6, 8, 10, or 12 memory channels.
- Use the same memory configuration in all populated memory channels.
- Use the same DIMM configuration for each processor socket.
- Use the same memory configuration for all NUMA domains in a single processor socket when using NPS=2 or NPS=4. "NPS" = NUMA node(s) per socket.

2.4 Memory Configuration Options

This section shows you which memory channel(s) to populate when using 1, 2, 4, 6, 8, 10, or 12 channels in a 1DPC configuration. It and also lists the performance of each option relative to the 12-channel configuration, meaning that 12-channel performance will equal 100%.

2.4.1 1-Channel Configuration

Figure 2-1 shows the ideal single-channel memory configuration. This will yield roughly 8.3% memory bandwidth performance compared to a 12-channel configuration. Using a greater number of lower-capacity DIMMs is the best way to boost memory bandwidth compared to this configuration. For example, if you need 128GB of RAM, then consider populating either:

- 2x64GB DIMMs for double the memory bandwidth performance
- 4x32GB DIMMs for quadruple the memory bandwidth performance

- 8x16GB DIMMs for eight times the memory bandwidth performance.

Note: The same concept of using more DIMMs of lower capacity applies to all memory channel configurations.

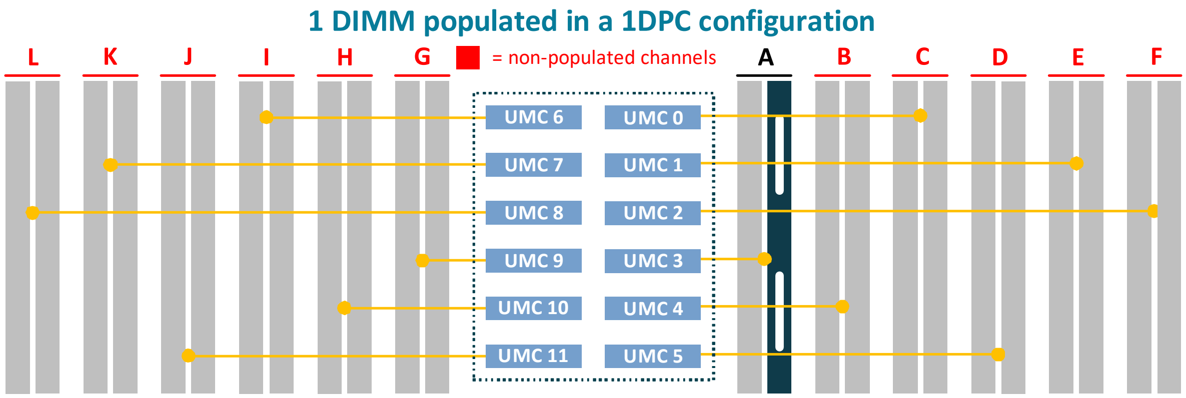

Figure 2-1: Single memory channel configuration (based on the AMD CRB)

2.4.2 2-Channel Configuration

Figure 2-2 shows the ideal two-channel memory configuration. This will yield roughly 16.6% memory bandwidth performance compared to a 12-channel configurations.

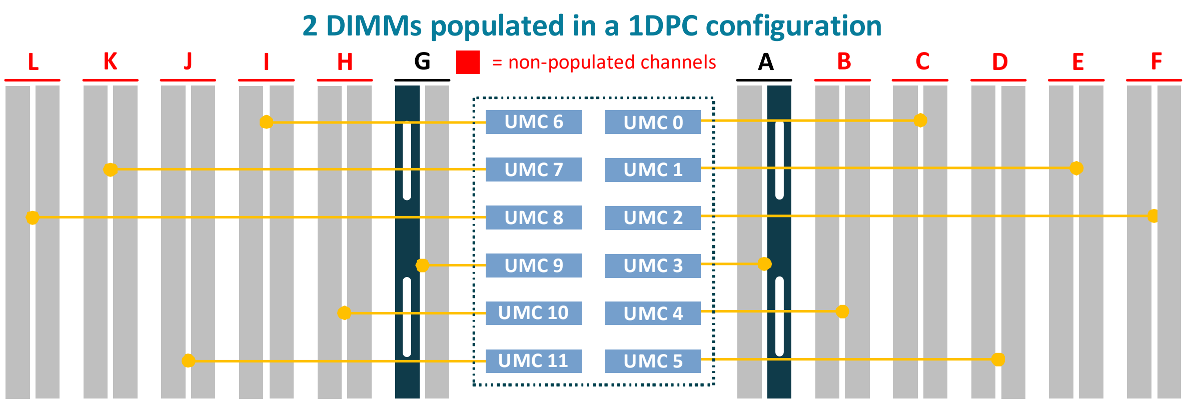

Figure 2-2: Two memory channel configuration (based on the AMD CRB)

2.4.3 4-Channel Configuration

Figure 2-3 shows the ideal four-channel memory configuration. This will yield roughly 33.3% memory bandwidth performance compared to a 12-channel configurations.

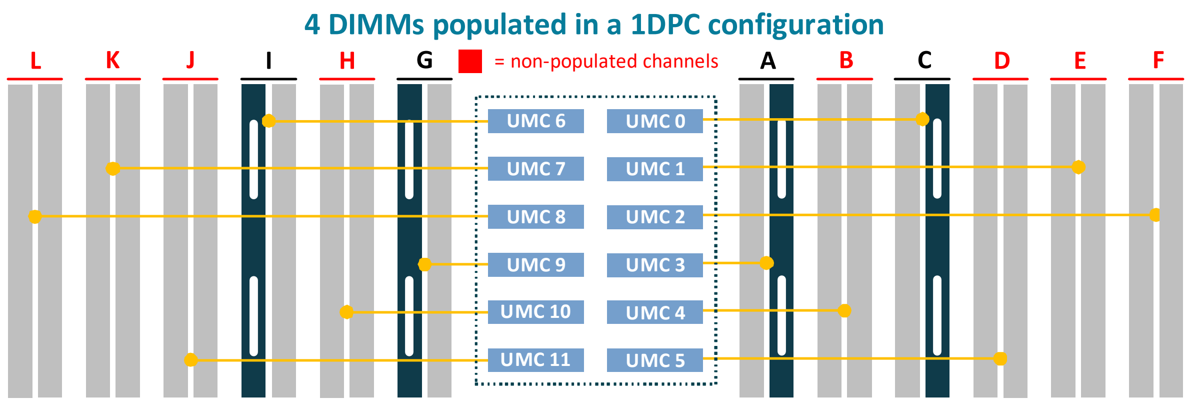

Figure 2-3: Four memory channel configuration (based on the AMD CRB)

2.4.4 6-Channel Configuration

Figure 2-4 shows the ideal six-channel memory configuration. This will yield roughly 50% memory bandwidth performance compared to a 12-channel configurations.

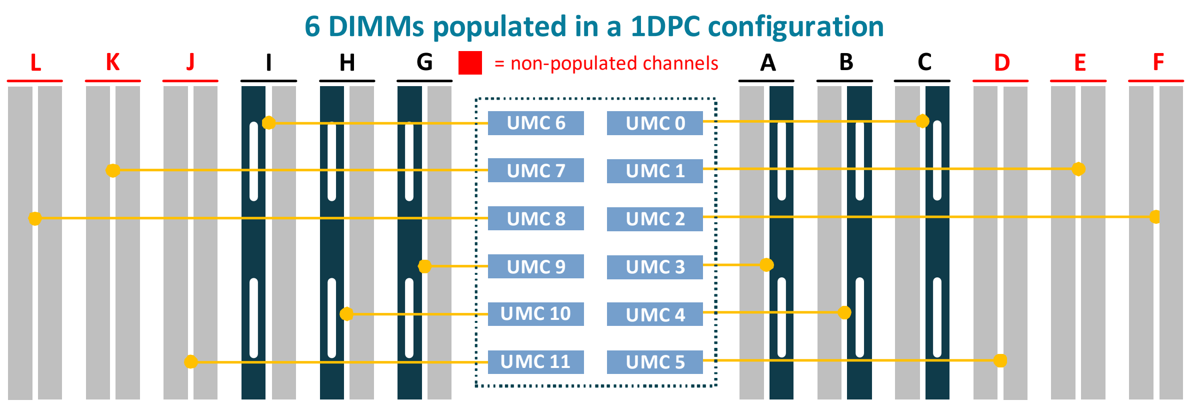

Figure 2-4: Six memory channel configuration (based on the AMD CRB)

2.4.5 8-Channel Configuration

Figure 2-5 shows the ideal eight-channel memory configuration. This will yield roughly 66.6% memory bandwidth performance compared to a 12-channel configurations.

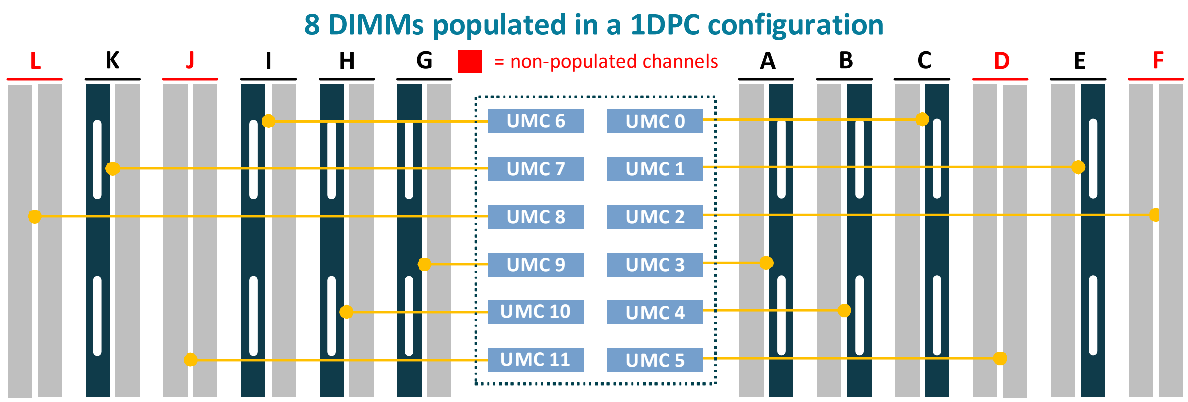

Figure 2-5: Eight memory channel configuration (based on the AMD CRB)

2.4.6 10-Channel Configuration

Figure 2-6 shows the ideal ten-channel memory configuration. This will yield roughly 83.3% memory bandwidth performance compared to a 12-channel configurations.

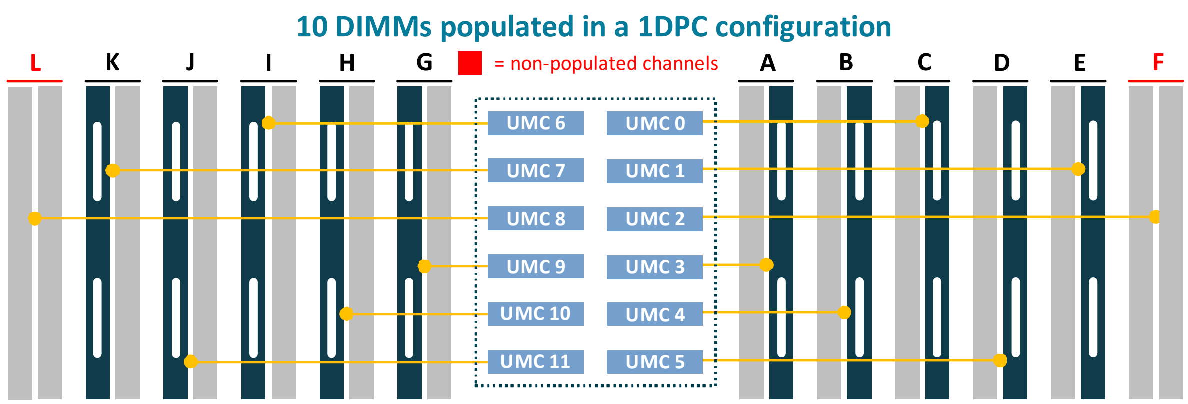

Figure 2-6: Ten memory channel configuration (based on the AMD CRB)

2.4.7 12-Channel Configuration

Figure 2-2 shows the ideal twelve-channel memory configuration, which yields 100% memory bandwidth performance.

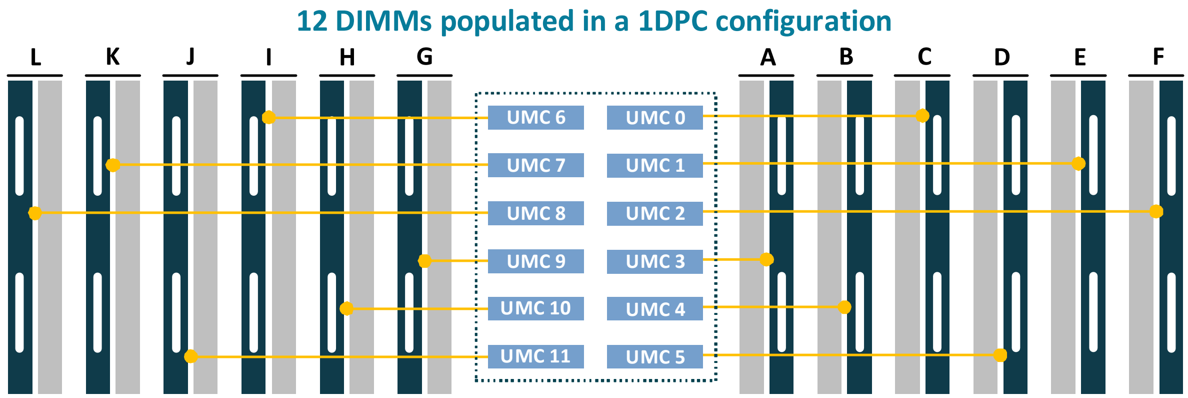

Figure 2-7: Twelve memory channel configuration (based on the AMD CRB)

2.5 Recommended Memory Speeds

Table 2-1 shows recommended memory speeds for a variety of memory types.

	DIMM Population*	DDR5 Frequency mT/s			Capacity (16 Gb x4 devices)
DIMM Type	DIMM 0	14-layer 93mil high-Dk PCB stack-up**	14-layer 74mil low-Dk PCB stack-up**	16-layer 93mil high-Dk PCB stack-up**	1 channel/ 12 channels
RDIMM***	1R (1 rank)	4800	4800	4800	32GB/384GB
	2R (2 ranks)	4800	4800	4800	64GB/768GB
3DS RDIMM	2S2R (4 ranks)	4800	4800	4800	128GB/1.5TB
	2S4R (4 ranks)	4800	4800	4800	256GB/3TB
	2S8Rx4 (16 ranks	4800	4800	4800	512GB/6TB

Notes:

* JEDEC nomenclature used to describe DDR5 DIMM types. DIMM 1 is the furthest distance from the processor for two memory slots per channel.

** Refer to the Socket SP5 Processor Motherboard Design Guide (PID 56870) for official descriptions and requirements for AMD EPYC 9004 Series Processor requirements. Platforms may require 14-layer or 16-layer stack-up, 93mil high-Dk or 74mil low-Dk PCB dielectric.

*** RDIMMs built from x4 and x8 devices are supported. The frequencies shown apply to both. The capacities listed only represent those of x4 DIMMs. RDIMMs built with x8 devices have half the capacity of the x4 RDIMMs with an equal number of ranks.

Table 2-1: Recommended memory speeds

Chapter 3 Memory Population by Workload

This chapter presents memory population recommendations for various workloads. These are general recommendations only; your actual needs and ideal configuration may vary widely from these recommendations based on your current and anticipated workload needs. Contact your server vendor or AMD for assistance.

3.1 Processor and Memory Sizing Guidelines

Table 3-1 presents general guidelines for 1DPC configurations for dedicated on-premises deployments.

Workload	# CPUs	Cores/ CPU	Total Cores	# DIMMS/ CPU	DIMM Size (GB)	Memory (GB)
CPU-based AI inference	2	96	192	12	64	1536
Application development & testing	1	32	32	8	64	512
Collaborative applications	2	64	128	8	128	2048
Content applications	1	64	64	8	128	1024
Private cloud infrastructure (mixed workloads/IaaS/SaaS/PaaS)	2	96	192	12	128	3072
Customer Relationship Management (CRM)	2	32	64	8	128	2048
Enterprise Risk Management (ERM)	2	32	64	8	128	2048
File and print	1	16	16	8	16	128
HPC CFD/weather/molecular dynamics	2	64	128	12	64	1536
HPC FEA implicit/explicit	2	32	64	12	64	1536
Media transcoding	2	96	192	8	64	1024
Media streaming	2	64	128	12	64	1536
Networking & management	1	16	16	8	16	128
Supply Chain Management (SCM)	2	32	64	8	128	2048
Security and appliances	1	16	16	8	16	128
Software-Defined Storage (SDS)	1	32	32	12	32	384
Structured data management and analytics (Large)	1	64	64	12	128	1536
Structured data management and analytics (Medium)	1	32	32	8	128	1024
Systems management	1	16	16	8	16	128
Unstructured data management and analytics	1	32	32	8	128	1024
Virtual Desktop Infrastructure (VDI) - core	2	64	128	12	128	3072
Virtual Desktop Infrastructure (VDI) - edge	1	16	16	12	32	384
Web serving & client tier	1	32	32	12	32	384

Table 3-1: General processor and memory sizing guidelines for dedicated on-premises deployments

3.2 Memory Recommendations by Workload

This section lists memory recommendations for several popular workload categories. Be sure to consult your server vendor or AMD for assistance with your specific needs.

3.2.1 High-Performance Computing (HPC)

Figure 3-1 shows the recommended memory for HPC workloads.

DIMM Size (GB) 1DPC	# of Memory Channels					
	2	4	6	8	10	12
32	64	128	192	256	320	384
64	128	256	384	512	640	768
96	192	384	576	768	960	1152
128	256	512	768	1024	1280	1536
256	512	1024	1536	2048	2560	3072

High-Performance Computing (HPC)

Figure 3-1: HPC memory recommendations

The performance of most HPC workloads improves significantly with the higher memory bandwidth enabled by using more memory channels.

3.2.2 Java™ Enterprise

Figure 3-2 shows the recommended memory for Java™ enterprise workloads.

DIMM Size (GB) 1DPC	# of Memory Channels					
	2	4	6	8	10	12
32	64	128	192	256	320	384
64	128	256	384	512	640	768
96	192	384	576	768	960	1152
128	256	512	768	1024	1280	1536
256	512	1024	1536	2048	2560	3072

Java memory allocation intensive
Java in-memory
Java general compute

Figure 3-2: Java enterprise memory recommendations

You can identify Java memory allocation intensive applications via application profiling. Java in-memory type applications act as local caching modules. Most non-critical Java applications (general compute) are not very memory intensive for capacity & bandwidth.

3.2.3 Databases

Figure 3-3 shows the recommended memory for database workloads.

DIMM Size (GB) 1DPC	# of Memory Channels					
	2	4	6	8	10	12
32	64	128	192	256	320	384
64	128	256	384	512	640	768
96	192	384	576	768	960	1152
128	256	512	768	1024	1280	1536
256	512	1024	1536	2048	2560	3072

Higher database capacity play
96-core OPNs
64- or 32-core OPNs

Figure 3-3: Database memory recommendations

Table 3-2 helps you refine memory requirements for small to VLDB (Very Large Database) databases across different database types.

Type	Small (GB)	Medium (GB)	Large (GB)	VLDB (GB)	Comments
RDBMS	4-16	16-128	128-1024	> 1024	Enterprise-grade RDBMS, such as Oracle and Microsoft SQL Server , have different memory size requirements based on the application profile (OLTP/OLAP/DSS) and database size. Open Ssource RDBMS, such as PostgreSQL, MySQL, and Maria DB are used for various purposes and also have varying memory size requirements.
In-Memory (IMDB)	16 -32	32-128	128-2048	> 2048	In-memory databases, such as TimesTen.
Hybrid	8-16	16-32	32-256	> 256	
NoSQL	32-128	128-256	256-512	> 512	

Table 4: Minimum database memory size requirements

3.2.4 Virtualization

Figure 3-4 shows the recommended memory for virtualization workloads.

DIMM Size (GB) 1DPC	# of Memory Channels					
	2	4	6	8	10	12
32	64	128	192	256	320	384
64	128	256	384	512	640	768
96	192	384	576	768	960	1152
128	256	512	768	1024	1280	1536
256	512	1024	1536	2048	2560	3072

Remote desktops
96-core OPNs
64- or 32-core OPNs

Figure 3-4: Virtualization memory recommendations

Remote desktop applications are normally bound to the system memory capacity. Use use all channels and smaller-size DIMMs. You can calculate VM memory capacities based on per-VM memory needs. Populating 6 to 8 memory channels when using 4th Gen AMD EPYC processors with 32 or 64 cores may be sufficient for your needs.

3.2.5 Other Workloads

Figure 3-5 shows the recommended memory for other workloads.

DIMM Size (GB) 1DPC	# of Memory Channels					
	2	4	6	8	10	12
32	64	128	192	256	320	384
64	128	256	384	512	640	768
96	192	384	576	768	960	1152
128	256	512	768	1024	1280	1536
256	512	1024	1536	2048	2560	3072

Compute & memory bandwidth intensive

FSI, etc.

Media, NGINX, etc.

Figure 3-5: Memory recommendations for other workloads

Compute and memory intensive use cases will benefit from populating 10 or 12 channels. Financial Services (FSI) workloads used for some cases such as High Frequency Trading may depend on both memory capacity and bandwidth. Most media and NGINX applications are not memory bandwidth bound and can deliver optimal performance with fewer populated memory channels.

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Chapter 4

Resources

4.1 Resources

Please see the following resources for additional information about AMD EPYC 8004 Series processors:

- AMD EPYC™ 9004 Series Server Processors
- AMD64 Architecture Programmer's Manual
- AMD EPYC™ Tech Docs and White Papers
- *BIOS & Workload Tuning Guide for AMD EPYC™ 9004 Series Processors* (available from AMD EPYC Tuning Guides)
- Memory Population Guidelines for AMD Family 19h Models 10h–1Fh - Login required; please review the latest version if multiple versions are present.
- Socket SP5 Platform NUMA Topology for AMD Family 19h Models 10h–1Fh - Login required; please review the latest version if multiple versions are present.

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