2nd HP Special Edition

DDR3

FOR DUMMIES ®

Learn to:

- **Choose your preferred DIMM type**

- **Get to the HP configuration tool online**

- **Avoid common mistakes**

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Brad Graham

®

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Infrastructure matters. It's the foundation for all the information and applications of your business. Server memory is one of the most critical components — even the slightest defect can result in downtime that could shut down your business. HP server memory can increase and improve the functionality of your servers and data centers.

DDR3
FOR
DUMMIES®
2ND HP SPECIAL EDITION

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Eric L. Pope, and Brad Graham**

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DDR3 For Dummies,® 2nd HP Special Edition

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Introduction

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*W*elcome to *DDR3 For Dummies*, 2nd HP Special Edition, a book with everything you need to know about DDR3, or Double Data Rate 3 memory, the latest generation high-speed memory for the HP ProLiant G6 and G7 servers. This new edition discusses memory population rules for AMD Opteron 6100 series and Intel Xeon 4-way servers and introduces new topics such as low voltage memory and LRDIMMs.

About This Book

This book is comprised of three parts:

- ✔ **Part I: Getting to Know DDR3.** Here you'll discover what's new about DDR3 and how it compares to DDR2. You'll learn about the two main types of DDR3: RDIMM (Registered DIMM) for performance and maximum memory capacity, and UDIMM (Unregistered DIMM) for price performance. You'll learn how to identify DDR3 DIMMs and understand per-channel restrictions.

- ✔ **Part II: Populating the Server.** There are guidelines for getting the best performance, and there are also rules about what works and what doesn't. You ought to follow the guidelines and you can't break the rules. And there's new information on AMD-based servers.

- ✔ **Part III: Ten Common Questions about DDR3.** This part finishes off the book with some common questions.

Terms Used in This Book

Before we get started, here are three acronyms (abbreviations) you'll see a lot in this book. They describe types of DDR3 memory. DIMM stands for dual inline memory module, and it's a memory module where the connectors (gold fingers) are different (electrically separated) on the front and back (whereas a SIMM, or single inline memory module, has the same connectors on the front and back, sort of like teeth on a comb). RDIMM and UDIMM are both types of DIMMs, of course. RDIMM is registered DIMM, and it has a register or buffer that puts less of an electrical load on the system's memory controller. UDIMM is unbuffered DIMM, and, smart reader that you are, you're probably guessing that RDIMM might be more versatile and UDIMM is more cost-effective. For more on the two different types of DIMM, see Part I.

Icons Used in This Book

This book uses icons to alert you to geeky, useful, and important factoids. The icons are:

This icon alerts you to extra information that helps you make sense of some of the more technical aspects of the part.

This icon points out helpful and useful information.

This icon points out super-important information.

Part I

Getting to Know DDR3

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In This Part

▶ Exploring DDR3

▶ Choosing between UDIMM and RDIMM

▶ Exploring some nuts and bolts

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A new generation of servers arrived in 2009 with new
CPUs. To maximize their performance, they used —
required — a new version of memory, called DDR3.
Spelled out, DDR3 SDRAM is shorthand for *double-data-
rate 3, synchronous dynamic random access memory.* This
is, as you might rightly expect, the third generation of
SDRAM where the memory uses each of the two phases of
the clock to achieve the double data rate. DDR3 is capable
of supporting more than twice the bandwidth of DDR2.

Why DDR3

You'll be happy to know DDR3 continues the pace of
energy efficiency. DDR2 ran at 1.8 volts, but the first
DDR3 modules run at 1.5 volts. DDR3 is now available at
1.35 volts (commonly referred to as DDR3L). In terms
of power consumed (watts), DDR3 is good for up to
25 percent improvement over DDR2. And DDR3 low volt-
age memory consumes roughly 15 to 20 percent less
power than DDR3 standard 1.5 volts.

Future DDR3L enhancements may drive power consumption even lower, into the ultra-low voltage range.

Speed matters. DDR3 helps make servers faster and more powerful. There are several reasons why you want DDR3 and not DDR2 or DDR (beyond the fact that memory slots are notched differently so you *have to* install the correct DIMMs). Here's why:

✔ **High performance.** DDR3 enables memory to run up to twice the speed of DDR2, which in turn had twice the speed of the initial DDR (what you might retroactively think of as DDR1). So in the span of less than a decade, DDR memory has improved the speed by 2 x 2 x 2, or by a factor of 8 times. At the same time, DDR3 continues to increase memory bandwidth beyond 2x that of DDR2.

Latency versus bandwidth is like quick versus fast. A car may do 0 to 60 in 3.5 seconds (latency) but has a top speed of 100 mph (bandwidth). (Okay, a car as described may not sound very likely, but it's just an illustrative example.)

✔ **Low power.** That's right, this is another less filling, tastes great story. The 1.5-volt DDR3 supply cuts power consumption by up to 25 percent over DDR2 memory, which ran at 1.8 volts. Eagle-eyed math wizards will notice that's a 12.5 percent drop in voltage, but we can explain: Other things are happening as well, and the power draw, expressed in watts, is down by about 25 percent. And wait, there's more. Future versions of DDR3 may reduce the operating voltage even further. Does anybody remember when memory ran on 5 volts and the drop to 3 volts was breathtaking? Now we're down to 1.35 volts. How low can we go?

TECHNICAL STUFF

DDR3 for HP

A few things make HP memory stand out:

- ✔ DDR3 memory was initially launched with 1.5 volts but 1.35 volts was added for Intel Xeon 5600 series, AMD Opteron 6100 series, and recently the Intel Xeon E7 family 4-way servers. Memory sizes are 1GB, 2GB, 4GB, 8GB, 16GB, and 32GB depending on the platform.

- ✔ On HP servers, ProLiant G6 and G7 platforms with Intel and AMD processors support DDR3 RDIMM and UDIMM but not mixed in the same unit. Four-way servers only support DDR3 RDIMM.

- ✔ All HP servers support Advanced ECC for better data integrity.

- ✔ For Intel-based HP servers, maximum capacity with RDIMM is as high as 384GB for 2P servers and now 2TB for 4P servers. Maximum capacity with UDIMM is 48GB for 2P servers.

- ✔ For AMD-based HP servers, maximum capacity with RDIMM is currently 256GB for 2P servers and 512GB for 4P servers. Maximum capacity with UDIMM is 64GB for 2P servers.

- ✔ Memory modules carry a one-year warranty or assume the longer warranty of the server they're inside.

HP DDR3 option kits contain a single DIMM module.

- ✔ **Higher bandwidth.** Server support for DDR3 runs up to 1333MT/s. DDR3 server architectures provide for a greater number of simultaneous memory accesses (more channels), which increases overall memory bandwidth.

Some in the industry refer to MHz as MT/s (mega-transfers per second). For a 667MHz clock the data transfer rate is 1333MT/s, hence double data rate.

✔ **High density.** DDR3 allows you to increase the memory footprint in your server with more DIMM slots.

✔ **Runs cooler.** Improved thermal characteristics allow each DIMM to run at lower temperatures. DDR3 runs cooler than DDR2.

When selecting DDR3 memory, options include:

✔ RDIMM (performance, maximum capacity) or UDIMM (generally more affordable, lower power)

✔ 2GB, 4GB, 8GB, 16GB, and now 32GB RDIMM modules; 1GB, 2GB, and 4GB UDIMM modules

✔ DDR3 speeds 1333, 1066, 800 MT/s

✔ DIMM speed depends on CPU capability, DIMM capability, and DIMMs installed

✔ ECC (error-correcting code)

Additional rules apply for HP servers. For details, see the sidebar "DDR3 for HP."

Choosing a DIMM Type

DDR3 comes in two main flavors, sort of like chocolate and vanilla. There's the all-powerful *RDIMM,* or *registered DIMM.* You can get more performance through massive memory footprints of up to 2TB in some cases. RDIMMs provide the same data error detection and correction supported by UDIMMs and also provide improved memory address error detection. The term *register DIMM* (it has a register) rather than *registered DIMM* (like

a registered guest) might be less confusing, but that's the way the terminology is used.

Then there's the bang-for-the-buck *UDIMM,* or *unbuffered* DIMM that consumes less power than equivalent RDIMMs in small memory footprints.

In the choice between RDIMMs and UDIMMs, the general rule is that RDIMMs are for larger, more powerful servers where you want more memory capacity and the best-possible level of error checking and error correction. UDIMMs are generally for smaller servers where affordability is important and yet you still get error correction. (Note that you can buy UDIMMs with no ECC, such as for gamer desktop PCs, but these aren't suitable for server applications. The server won't be damaged, but it won't boot, either.) For a quick look at the comparisons between the two types, see Table 1-1.

Read this book and if you are still not sure, go with RDIMM for more flexibility.

By the way, you have to choose one DIMM type. You can't mix and match RDIMM and UDIMM inside the same server. What happens if you mix? The server won't boot.

Table 1-1	Choices in Memory Technology	
	RDIMMs	*UDIMMs*
Capacities	2GB, 4GB, 8GB, 16GB, 32GB	1GB, 2GB, 4GB
Maximum DIMMs per channel	3 dual rank	2 dual rank

(continued)

Table 1-1 *(continued)*

	RDIMMs	*UDIMMs*
Low power option	4GB, 8GB, 16GB, 32GB	4GB
Address error detection	Yes	No
Lower cost	No	Yes, most of the time
Ranks/DIMM support	1, 2, 4	1, 2
DRAM support	×4, ×8	×8
Maximum server capacity (at introduction)	Intel: 384 (18 slots) and 2TB (64 slots) AMD: 256 (24 slots) and 512GB (48 slots)	Intel: 48 (12 slots) AMD: 64 (16 slots)

Registered DIMM (RDIMM)

RDIMM stands for *registered dual in-line memory module.* Of the two flavors of DDR3 memory, this is the more capable (compared to UDIMM). It's generally the right choice for higher-end servers where you need lots of RAM and the highest-possible reliability. The RDIMM has a register integrated to capture and retransmit signals locally. As a result, the system sees only one load per address line instead of 9, 18, or 36. RDIMM allows loading of more memory in servers. RDIMM provides greater reliability at a slight cost in performance of one clock cycle to affected signals.

Comparing DDR3 to DDR2

DDR3 has it all over DDR2 on performance, speed, good looks, you name it. Here's a quick rundown:

- ✔ **Speed:** DDR3 runs at twice the speed of DDR2, which ran twice as fast as DDR, which . . . you get the idea. Basically, memory needs to be faster to keep up with ever-faster CPUs, and that's where DDR3 comes in.

- ✔ **Power:** The first memory chips ran at 5 volts. Over the years, voltage needs dropped. DDR3 chips run at 1.5 volts, while DDR2 chips ran at 1.8 volts. Low-voltage DDR3L memory is now down to 1.35 volts. That translates to over 70 percent in power savings alone since DDR2. We've come a long way!

RDIMM is architected to resolve capacity problems. You can add more memory and keep the DIMM count low. *Quad-rank DIMMs* allow for higher capacity per DIMM. RDIMMs allow for 1, 2, or 4 ranks/DIMM support. For Intel and AMD servers, there can be a maximum of 8 ranks per channel (two 4-rank DIMMs per channel).

Rank is a group of DRAM chips that are ganged together to provide 64 bits of data on the memory bus (72 bits wide if you're using ECC memory). Each chip in the rank provides 4 bits (x4 chips, pronounced "by four") or 8 bits (x8) of data. To have the 64-bit data bus, you need ranks of 16 x 4 or 8 x 8 chips. (Or 18 or 9 for ECC memory.) DDR3 supports

single-, dual-, and quad-rank DIMMs. A quad-rank DIMM, for example, has four sets or ranks of DRAM chips on the module.

RDIMM can be used in most HP servers (ML110 and MicroServer only support UDIMM). Capacities are 2GB, 4GB, 8GB, 16GB, and 32GB. In an 18-slot server, you could have as much as 384GB of DDR3 RDIMM installed.

Unbuffered DIMM (UDIMM)

Unbuffered DIMM or UDIMM represents a more cost-effective approach. The full name is *unbuffered dual in-line memory module*. Sometimes UDIMM is also called *unregistered DIMM,* which is also correct, since UDIMMs lack the register of RDIMMs. (And sometimes you'll see it spelled as *U-DIMM*. Take your pick.) Their uses extend beyond servers. Some workstation PCs employ DDR3 UDIMMs, and some ultimate gamers use DDR3 UDIMMs for performance.

> **TIP**
> All UDIMMs used in HP ProLiant servers are — must be — ECC UDIMMs. ECC stands for error-correcting code. That's one more thing to remember, and not mess up, for people trying to save a few bucks shopping for memory outside HP. If non-ECC memory is installed in an HP server, the server won't boot.

> **REMEMBER**
> ECC UDIMM can be used for low-end server segments. It's generally for lower price, smaller memory capacity, entry-level servers that employ only one or two DIMMs per channel.

TECHNICAL STUFF

Load reduced DIMM (LRDIMM)

It's worth a brief mention about *load reduced* DIMM or LRDIMMs. The vast majority of server customers will choose RDIMMs and UDIMMs, but some customers want massive memory expansion without sacrificing performance when loading up to three DIMMs per channel (DPC).

LRDIMM's main advantage is to increase capacity by fooling the memory controller to think there are fewer ranks per channel. How do they do this? The register on RDIMMs is expanded to buffer the data bus in addition to the address/command bus. This reduces the electrical load to the memory controller. This buffer is called (you guessed it) a load reduction (LR) buffer or memory buffer (MB). The LR Buffer lets a quad rank DIMM look like a dual rank DIMM to the memory controller. LRDIMMs allow up to three DIMMs per channel since that's still below the eight rank per channel limit. In summary, greater capacity using fewer ranks. Pretty cool stuff for those fascinated by DDR3.

One main drawback is that you can't mix LRDIMMs with either RDIMMs or UDIMMs. It's all or nothing. LRDIMMs are for folks who want absolute maximum capacity and increased performance. When they are available, LRDIMMs may be supported on HP servers.

Installation

Installing DDR3 memory is physically easy, especially since the slots are color-coded on most HP servers. Memory slots are colored white and black, the white slots being where you install the first memory module on each channel. It does take a bit of advance work, but not a lot.

Memory Protection

ProLiant G6 and G7 servers offer several levels of memory protection (see Table 1-2):

- ✔ **ECC** or error-correction code is the fundamental form of ProLiant memory protection. *Parity,* as in parity error (you very occasionally get parity errors on a desktop PC), tells you something went wrong, as in wrong and it can't be made unwrong. ECC is based on advanced mathematics, and there's a fancy formula to tell you how much you need ($\log_2(N)+1$ where N is the number of data bits) or this simple explanation: To protect 64 bits of data, you need 8 redundant bits. How good is it? ECC memory can detect and correct single-bit errors (the vast majority), can detect double-bit errors, and might detect (sorry, no guarantee) errors greater than double-bit.

- ✔ **Advanced ECC (multiple-bit error detection)** is ECC on steroids, except in this case steroids are good and won't get you tossed out of the Olympics. Advanced ECC requires 16 redundant bits to protect a 128-bit word. It's able to detect and correct up to 4 data bits. With Advanced ECC, you can protect against the loss of a single DRAM

device. The data bus is divided into groups of 4 bits each, and any group can have all 4 bits in error so long as the other groups are okay. It's able to detect 2-bit errors occurring in different groups. If 4-bit-wide DRAMs are used, then one DRAM represents one group on the bus.

✔ **Mirrored memory protection** is just like a mirrored hard disk drive. You have twice as much as you need. Half is configured as system memory, and half is mirrored memory. Data is written to both places. Reads are from the system memory unless — you've probably guessed this — there's an uncorrectable system error.

Table 1-2	Advanced Memory Protection	
	Basic ECC Technology	*HP Advanced ECC Technology*
Device failure protection	No	Yes
Industry-standard DIMMs	Yes	Yes
Hot plug	No	No
Failed DIMM -replacement	Offline	Offline
Memory expansion	Offline	Offline
Additional memory expense	0%	0%

Identifying HP DIMMs

Here's how to read the fine print on product selector guides (see Figure 1-1 for a visual). HP certified memory will have these markings, from left to right:
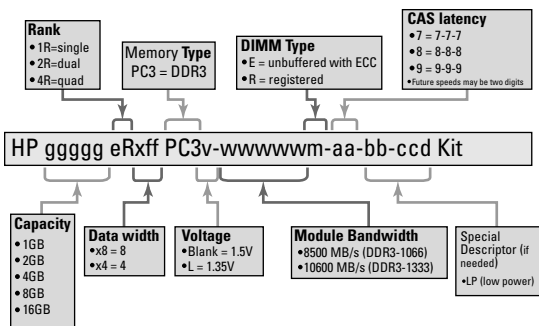
Figure 1-1: DDR3 part number description format.

- ✔ **HP** indicates it's HP-approved memory being sold through an HP channel or direct from HP
- ✔ **ggggg** indicates the capacity, 1, 2, 4, 8, 16, or 32 GB
- ✔ **eR** indicates rank, 1R (single), 2R (dual), or 4R (quad)
- ✔ **xff** is the data width, x8 = 8 bit, x4 = 4 bit
- ✔ **PC3** is the memory type, PC3 being DDR3
- ✔ **v** is the voltage, 1.5V if blank, L being 1.35V
- ✔ **wwwwww** is the module bandwidth, 8500MB/s = DDR3-1067, 10600MB/s = DDR3-1333
- ✔ **m** is the DIMM type, E for unbuffered ECC, R for registered
- ✔ **aa** is CAS latency (column address strobe, or DRAM real time in bus clocks), 7=7-7-7, 8=8-8-8, 9=9-9-9 (note that future speeds may use a two-digit indicator)

- ✔ **bb-ccd** is a special descriptor if needed, for example, LP for low power
- ✔ **Kit** at the end indicates it's an HP kit (and remember that with DDR3 there's one module per kit, not two)

For example, **500670-B21 HP 2GB 2Rx8 PC3-10600E-9 Kit** indicates an HP DIMM with a 2GB capacity, dual rank, a data width of 8, memory type of DDR3, 10600 unbuffered ECC, 9-9-9 latency, and an HP kit.

DIMMs per Channel Restrictions

A *memory channel* refers to DIMM slots tied to the same wires on the CPU. Multiple memory channels allow for faster operation, theoretically allowing memory operations to be up to four times as fast. Dual channel architecture with 64-bit systems provides a 128-bit data path. Memory is installed in banks, and you have to follow a couple of rules to optimize performance. With the HP Intel 5500 and 5600 series ProLiant G6 and G7 servers, there are three channels from each processor. HP AMD Opteron 6100 series have an extra fourth channel for each processor. Four CPU servers have eight channels per processor, all of which is covered in Part II.

You can install up to two UDIMMs per channel or three RDIMMs per channel in both HP Intel 5500/5600 ProLiant series and HP AMD Opteron 6100 series ProLiant servers. Population rules must be followed or errors will occur. That is:

- ✔ Same DIMM type; RDIMM and UDIMM can't be mixed
- ✔ Same size is recommended for performance; however, it is possible to mix capacities

- ✔ Same speed
- ✔ Same technology (DDR3); DDR and DDR2 modules won't fit, physically, in a DDR3 socket

Channel rules and restrictions are covered in more detail in Part II.

HP Part Number Matters (Not Vendor Name)

When buying memory through HP, remember that DIMMs do not have to be from the same vendor. DIMMs are JEDEC standard. All DIMMs sourced through HP pass HP memory qualification tests.

In brief: If the HP part number is the same, the DIMMs are compatible.

Part II

Populating the Server

. . . .

In This Part

▶ Knowing rules to follow (and why)

▶ Populating in the proper order

. . . .

*I*n this part, we go over the nitty-gritty about populating the memory slots. The rules may seem overwhelming at first. Some rules you have to follow to make sure the server runs. Others you want to follow to optimize performance. The rules vary depending on whether you're installing UDIMMs or RDIMMs and how many memory slots your server has. Some are pretty obvious, at least in hindsight, like not installing memory connected to the second processor if you've only got one CPU in your server.

What's new in this latest edition includes information on how to populate DDR3 memory for AMD, which besides the extra memory channel per processor, begins with populating the channel and slot farthest from the processor. Then we spend some time reviewing the memory population rules for 4 way servers.

What follows here is wisdom likely to survive the ages, or at least the next couple years, but always check online for the best and latest.

For more information and the latest information on configuring your HP server with DDR3 memory, go to www.hp.com/go/ddr3memory-configurator.

Population Rules – Intel Xeon 5500 and 5600 Series Servers

These are the key rules to follow when populating memory slots on ProLiant Intel–based G6 and G7 servers. This is not the complete list but covers most HP ProLiant servers. Rules for 4, 6, and 16 slot servers (ML110, DL120, DL170 respectively) can be found in the HP QuickSpecs (http://h18000.www1.hp.com/products/quickspecs). Also see Figure 2-1.

For servers with 18 memory slots:

▮ ✔ There are three DIMM slots for each memory channel; 18 total slots (two CPU servers).

For servers with 12 memory slots:

▮ ✔ There are two DIMM slots for each memory channel; 12 total slots (two CPU servers).

For servers with 9 memory slots:

▮ ✔ There are three DIMMs slots for each memory channel; 9 total slots (one CPU server).

For all Intel-based ProLiant G6 and G7 servers, with either 12 or 18 slots:

- ✔ There are three channels per processor; six channels per server in two-CPU servers.
- ✔ Memory Channel 1 comprises the three DIMMs closest to the processor. Memory Channel 3 comprises the three DIMMs farthest from the processor.
- ✔ Populate the white DIMM slots first.
- ✔ Don't mix UDIMMs with RDIMMs.
- ✔ Don't install DIMMs if there's no corresponding processor installed. If there's only one CPU in a two-CPU system, only half the DIMM slots are available.
- ✔ You can have up to eight ranks installed per channel.
- ✔ You can install two quad-rank DIMMs per channel.
- ✔ To maximize performance, balance the memory capacity among installed processors.
- ✔ Go wide before deep across the processors; spread DIMMs across channels, starting farthest from the CPU.
- ✔ Load the channels identically if possible.
- ✔ Populate DIMMs from heaviest load (quad-rank) to lightest load (single-rank) within a channel. The heaviest load (DIMM with most ranks) within a channel goes farthest from the chipset.

DIMM TYPE ->		Registered Dimms (RDIMMS)					ECC DIMMs	
DIMM Rank ->	Single Rank	Dual Rank (2R)			Quad Rank (4R)		Dual Rank (2R)	
DIMM Capacity ->	4GB	2GB	8GB	16GB	16GB	32GB	2GB	4GB
DIMM Native Speed (MHz) ->	1333	1333	1333	1333	1066	1066	1333	1333
Voltage	LV/Std	Std	LV/Std	LV	Std	LV	Std	LV/Std
SLOTS THAT CAN BE POPULATED								
9 slot servers	9	9	9	9	6	6	6	6
12 slot servers	12	12	12	12	12	12	12	12
16 slot servers	16	16	16	16	12	12	12	12
18 slot servers	18	18	18	18	12	12	12	12
Maximum Capacity (GB)								
9 slot servers	36	18	72	144	96	192	12	24
12 slot servers	48	24	96	192	192	384	24	48
16 slot servers	64	32	128	256	192	384	24	48
18 slot servers	72	32	144	288	192	384	24	48
POPULATED DIMM SPEED (MHz)								
1 DIMM Per Channel	1333	1333	1333	1333	1066	1066	1333	1333
2 DIMM Per Channel	1066/1333*	1333	1066/1333*	1066/1999*	800	800	1333	1333
3 DIMM Per Channel	800**	800**	800**	800**	n/a	n/a	n/a	n/a

*2DPC: Std voltage DIMMS run at 1333. By default, LV DIMMS run at Std voltage (1.5V) and operate at 1333. For power savings, RBSU can be changed to operate at 1066 and run at 1.35V.

**3DPC: LV Std voltage runs at 800

Figure 2-1: Memory options for HP DDR3.

If you're installing UDIMMS:

- ✔ You can install only two UDIMMs per channel; if available, the third slot in the channel must remain empty. (RDIMMs can use all three.)

- ✔ For memory mirroring mode, Channel 3 must be unpopulated. Channels 1 and 2 are populated identically.

Other Intel population notes:

- ✔ For lock-step mode, Channel 3 must be unpopulated. DIMMs in Channels 1 and 2 will be installed in pairs. The paired slots will be 1,4; 2,5; 3,6 on a 3DPC system or 1,3; 2,4 on a 2DPC system.

- ✔ Mixing voltage is allowed, but DIMMs will run at the higher of the two voltages.

- ✔ Mixing DIMM speeds is allowed, but DIMMs will run at the slower of the two speed ratings.

Populating Alphabetically

To populate your server most efficiently, it's best to first populate channels that are farthest away from the processor. So for a 12 DIMM slot server, you'd first populate the second slot in Channel 1, then the fourth slot in Channel 2, and finally, the sixth slot in Channel 3. The rules are similar for 18 DIMM slots.

For a quick guide on how to populate your slots for a 12 DIMM slot server, check Table 2-1. Install DIMMs in alphabetical order. So look at the Population Order column. You'd install into the A slot first, installing into Slot 2, then place B into slot 4 and so on down the alphabet. The rules are the same for CPU1 and CPU2.

Table 2-1	12 DIMM Slots CPU1 and CPU2	
	Slot #	*Population Order*
Channel 1	1	D
	2	A
Channel 2	3	E
	4	B
Channel 3	5	F
	6	C

For a quick guide on how to populate your slots for an 18 DIMM slot server, check Table 2-2. Install DIMMs in alphabetical order. So look at the Population Order column. You'd install into the A slot first, installing into slot 3, then place B into slot 6, and so on down the alphabet. The rules are the same for CPU1 and CPU2.

Table 2-2	18 DIMM Slots for CPU1 and CPU2	
	Slot #	*Population Order*
Channel 1	1	G
	2	D
	3	A

	Slot #	Population Order
Channel 2	4	H
	5	E
	6	B
Channel 3	7	I
	8	F
	9	C

Much more information is available via the HP DDR3 online configuration tool: `www.hp.com/go/ddr3memory-configurator`.

Population Rules — AMD Opteron 6100 Series Servers

Because AMD servers have an extra memory channel per CPU, the rules, though similar in principle, are fairly unique. This section goes over the key rules to follow for HP ProLiant G7 2 CPU servers using the AMD Opteron 6100 series processor. Also see Figure 2-2.

For servers with 16 memory slots:

> ✔ There are two DIMM slots for each memory channel; 16 total slots (two CPU servers).

DIMM TYPE ->	Registered Dimms (RDIMMS)			ECC DIMMs	
DIMM Rank ->	Single Rank	Dual Rank (2R)		Rank (4R)	Dual Rank (2R)	
DIMM Capacity ->	4GB	2GB	8GB	16GB	2GB	4GB
DIMM Native Speed (MHz) ->	1333	1333	1333	1066	1333	1333
Voltage	LV/Std	Std	LV/Std	Std	Std	Std
SLOTS THAT CAN BE POPULATED						
16 slot servers	16	16	16	16	16	16
24 slot servers	24	24	24	8	24	24
Maximum Capacity (GB)						
16 slot servers	64	32	128	256	32	64
24 slot servers	96	48	192	256*	32	64
POPULATED DIMM SPEED (MHz)						
1 DIMM Per Channel	1333	1333	1333	1066	1333	1333
2 DIMM Per Channel	1333	1333	1333	1066	1333	1333
3 DIMM Per Channel	1066/1333**	1333	800/1066**	n/a	n/a	n/a
*This capacity is achieved by loading one 16GB in center socket and remaining sockets with 8G DIMMs						
** 3DPC: LV runs at 800; Std voltage runs at 1066						

Figure 2-2: Memory Options for HP DDR3 – AMD 2 CPU servers.

For servers with 24 memory slots:

- ✔ There are three DIMM slots for each memory channel; 24 total slots (two CPU servers).

For all ProLiant G7 servers (AMD), 16 or 24 slot:

- ✔ There are four channels per processor; eight channels per server in a two-CPU server.
- ✔ Memory channel 1 comprises the three DIMMs furthest from the processor. Memory channel 4 comprises the three DIMMs closest to the processor.
- ✔ Don't mix UDIMMs with RDIMMs.
- ✔ You can only have up to eight ranks installed per channel.
- ✔ If only one processor is installed (in two processor systems), only half of the DIMM sockets are available. The same applies in a two processor configuration in a four-processor-capable system.

For AMD servers with 16 slots:

- ✔ Within a channel, populate DIMM slot 1 (furthest from processor) then 2 should be populated in that order.
- ✔ Heaviest load (DIMM with most ranks) within a channel goes furthest from the chipset.
- ✔ Up to two QR DIMMs can be put on each channel.

For AMD servers with 24 slots:

- ✔ Within a channel, populate DIMM slot 1 (furthest from processor), then 3 (closest to processor), then 2 (middle) should generally be populated in that order unless QR is present.

- ✔ Heaviest load (DIMM with most ranks) within a channel goes furthest from the chipset.

- ✔ Up to one QR DIMM can be put on each channel (center slot). If present, this slot could be populated out of order and DIMM slot 1 and DIMM slot 3 should be installed in that order.

To maximize performance, balance the memory capacity among installed processors:

- ✔ Go wide before deep across the processors; spread DIMMs across channels, starting farthest from the CPU.

- ✔ Load all channels on a processor similarly if possible.

- ✔ Load all installed processors in a system similarly if possible.

If you're installing UDIMMs:

- ✔ Only two UDIMMs per channel can be installed. For 3 slot per channel servers, the middle channel remains empty.

Other AMD population notes:

- ✔ For online spare mode, the DIMM with the largest size rank (one quarter of the capacity of a QR DIMM, one half the capacity of a DR DIMM or the entire capacity of a SR DIMM) will have one rank assigned as a spare and not available to the customer.

- ✔ Mixing voltage is allowed, but DIMMs will run at the higher of the two voltages

- ✔ Mixing DIMM speeds is allowed, but DIMMs will run at the slower of the two speed ratings.

Populating Alphabetically – AMD Servers

To populate your AMD server most efficiently, it's best to populate channels that are furthest away from the processor. So for a 16 DIMM slot server, for each CPU you'd first populate the first slot in Channel 1, then the fifth slot in Channel 3, then the third slot in Channel 2, and so on.

For a quick guide to what order to populate your slots for a 16 DIMM slot server, check out Table 2-3. Install DIMMS in alphabetical order. So look at the Population Order column. You'd install into the A slot first, installing into slot 1, then place B into slot 5, and so on down the alphabet. The rules are the same for CPU1 and CPU2.

Table 2-3	16 DIMM Slots CPU1 and CPU2	
	Slot #	*Population Order*
Channel 1	1	A
	2	E
Channel 2	3	C
	4	G
Channel 3	5	B
	6	F
Channel 4	7	D
	8	H

For a quick guide to what order to populate your slots for a 24 DIMM slot server, check on Table 2-4. Install DIMMS in alphabetical order. So look at the Population Order column. You'd install into the A slot first, installing into slot 1, then place B into slot 7, and so on down the alphabet. The rules are the same for CPU1 and CPU2.

Table 2-4	24 DIMM Slots for CPU1 and CPU2	
	Slot #	*Population Order*
Channel 1	1	A
	2	I
	3	E
Channel 2	4	C
	5	K
	6	G
Channel 3	7	B
	8	J
	9	F
Channel 4	10	D
	11	L
	12	H

Much more information is available via the HP DDR3 online configuration tool: `www.hp.com/go/ddr3 memory-configurator`.

Population Rules — 4-Way Intel Servers

The latest Intel Xeon-EX processor benefits from a NUMA architecture (NUMA stands for Non-Uniform Memory Architecture), which gives each processor greater access to the memory.

But for even greater memory bandwidth, each Intel Xeon E7 family and 6500/7500 series processor gets help from two memory controllers that each employ two memory buffers (sometimes referred to as BoB or buffer on board). Each BoB supports 4 DIMM sockets and so a single processor can access 16 DIMMs. For a visual, see Figure 2-3.
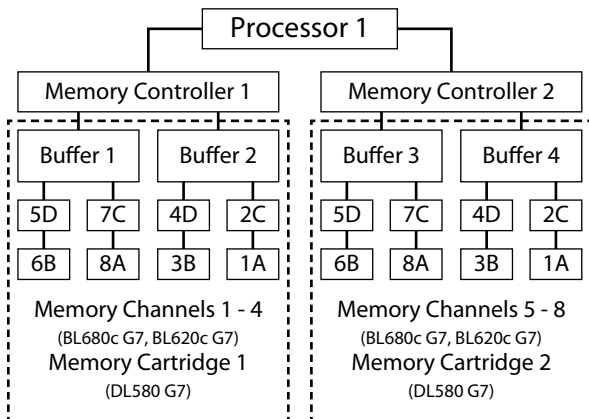
Figure 2-3: Intel XEON EX memory architecture.

These are the key rules to follow when populating memory slots on ProLiant Intel Xeon-EX based servers. (Also see Figure 2-4).

For servers with 64 slots:

- ✔ DL580 G7: There are two DIMM slots per channel, 4 channels per cartridge; 2 cartridges per CPU; total 64 slots on a four CPU server.

- ✔ BL680c G7: There are two DIMM slots per channel; 8 channels per CPU; total 64 slots on a four CPU server.

For servers with 32 slots:

- ✔ BL620c G7: There are two DIMM slots per channel; 8 channels per CPU; total 32 slots on a two CPU server.

For all servers using the Intel-EX processors:

- ✔ DIMMs should be installed in pairs with identical characteristics (same density, speed, and rank). In other words, HP recommends using DIMMs with identical part numbers for each pair. This helps achieve maximum performance.

- ✔ DIMM pairs must be populated in sequence by letter designation. For example, install DIMM pair (1A, 8A) first, followed by DIMM pair (3B, 6B), then DIMM pair (2C, 7C) and so on.

- ✔ The minimum configuration is two DIMMs per cartridge (or channel). Running in Lockstep, DIMM pairs offer more memory protection for increased memory fault resiliency.

- ✔ Highest rank DIMMs should be installed in the white connector locations, which are farthest from the CPU.
- ✔ Failure to follow these rules may result in memory errors, reduced memory performance, or even the inability to recognize memory.
- ✔ UDIMMs are not supported
- ✔ Low voltage 1.35v DIMMs are supported on the Intel Xeon processor E7 family only. *Note:* Low voltage DIMMs aren't supported on the Intel Xeon 6500 and 7500 series processors.

DIMM TYPE ->		Registered Dimms (RDIMMS)				
DIMM Rank ->	Single Rank	Dual Rank (2R)			Rank (4R)	
DIMM Capacity ->	4GB	2GB	8GB	16GB	16GB	32GB
DIMM Native Speed (MHz) ->	1333	1333	1333	1333	1066	1066
Voltage	LV/Std	Std	LV/Std	LV	Std	LV
SLOTS THAT CAN BE POPULATED						
32 slot servers	32	32	32	32	24	24
64 slot servers	64	64	64	64	48	64
Maximum Capacity (GB)						
32 slot servers	128	64	256	512	512	1TB
64 slot servers	256	128	512	1024	1024	2TB
POPULATED DIMM SPEED (MHz)						
1 DIMM Per Channel	1066	1066	1066	1066	1066	1066
2 DIMM Per Channel	1066	1066	1066	1066	1066	1066

All DIMM configurations are rated at 1066. However, actual speed is dependent on highest possible speed for a given processor. Memory speed is a function of the processors QPI bus speed.

Figure 2-4: Memory Options for HP DDR3 – Intel 4 CPU servers.

Hemisphere mode

To maximize performance (called Hemisphere mode) on Intel Xeon-EX servers:

- ✔ Hemisphere mode is enabled when processors in the system have identical DIMM population behind both of their memory controllers.

- ✔ To achieve maximum memory bandwidth performance, populate both memory controllers for each installed processor.

- ✔ Minimum recommended DIMM count is eight DIMMs installed in DIMM pair locations A, B, C, and D on each installed processor. In other words, populate at least four DIMMs per channel or cartridge.

- ✔ Greater performance is obtained when all memory controllers are populated with either four or eight dual- or quad-rank DIMMs.

- ✔ Maximum throughput is achieved when all DIMM slots are fully populated with the maximum number of eight quad-rank DIMMs per memory controller.

- ✔ Hemisphere mode is controlled via an RBSU option, enabling the user to select either automatic (default) or disable.

- ✔ In automatic mode, the BIOS enables Hemisphere mode if the system memory configuration is compatible with Hemisphere mode.

- ✔ Hemisphere mode should produce the best overall performance for a variety of applications. However,

> Hemisphere mode can be disabled if it produces lower performance for a particular application.
>
> ✔ Mirrored Memory mode isn't supported when Hemisphere mode is enabled.
>
> ✔ Much more detailed information is available in the HP ProLiant DL580 G7 and BladeSystem BL680c G7 and B620c G7 User Guides.

Populating Alphabetically

For a quick reference on how to populate a 64 DIMM slot server (the DL580 G7) using cartridges, see Figure 2-5. So look at the Population Order column. You'd install both As in slots 1 and 8 first, then install Bs in slots 3 and 6, then Cs in slots 2 and 7, and Ds in slots 4 and 5. The population order is the same for all eight cartridges.

For a quick reference on how to populate a 32 and 64 DIMM slot server (BL620c G7 and BL680c G7), see Figure 2-6. Look at the Population Order column. You'd install into the As in slot 4 and 5, then install Bs in slots 12 and 16, Cs in slots 2 and 7, Ds in slots 10 and 14, and so on. These rules apply to both the 32 socket DL620c G7 and 64 slot BL680c G7 servers.

CPU 1

Cartridge 1	Slot #	Population Order
	1	A
	2	C
	3	B
	4	D
	5	D
	6	B
	7	C
	8	A

CPU 2

Cartridge 3	Slot #	Population Order
	1	A
	2	C
	3	B
	4	D
	5	D
	6	B
	7	C
	8	A

CPU 3

Cartridge 5	Slot #	Population Order
	1	A
	2	C
	3	B
	4	D
	5	D
	6	B
	7	C
	8	A

Cartridge 2	Slot #	Population Order
	1	A
	2	C
	3	B
	4	D
	5	D
	6	B
	7	C
	8	A

Cartridge 4	Slot #	Population Order
	1	A
	2	C
	3	B
	4	D
	5	D
	6	B
	7	C
	8	A

Cartridge 6	Slot #	Population Order
	1	A
	2	C
	3	B
	4	D
	5	D
	6	B
	7	C
	8	A
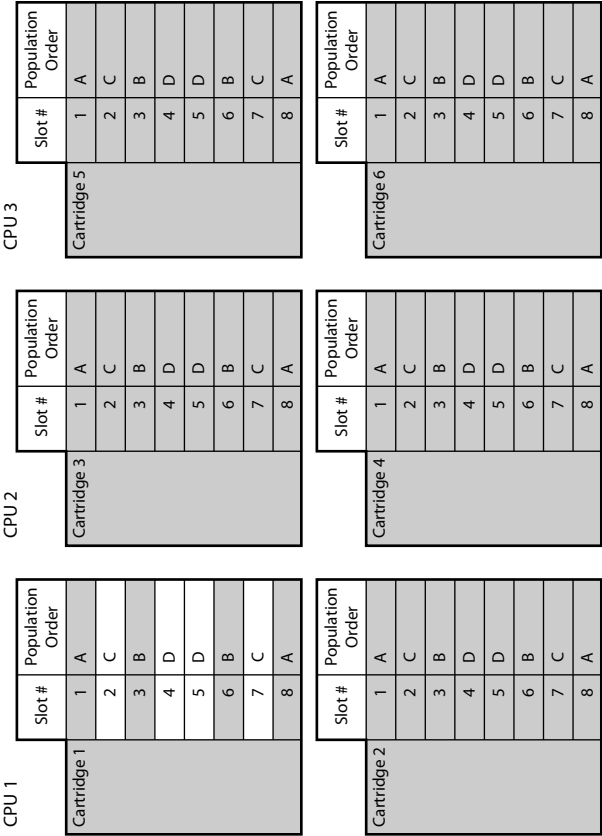
Figure 2-5: 64 DIMM Slots with Cartridges CPU1-CPU4.

CPU 3

Slot #	Population Order
Channel 5	
1	G
2	C
3	E
4	A
5	A
6	E
7	C
8	G
Channel 6	
9	H
10	D
11	F
12	B
13	H
14	D
15	F
16	B

CPU 2

Slot #	Population Order
Channel 3	
1	G
2	C
3	E
4	A
5	A
6	E
7	C
8	G
Channel 4	
9	H
10	D
11	F
12	B
13	H
14	D
15	F
16	B

CPU 1

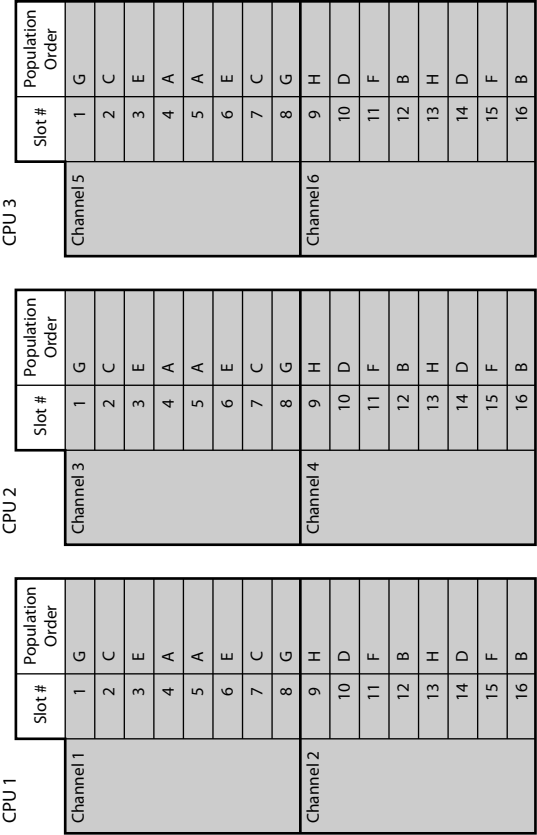| Slot #	Population Order
Channel 1	
1	G
2	C
3	E
4	A
5	A
6	E
7	C
8	G
Channel 2	
9	H
10	D
11	F
12	B
13	H
14	D
15	F
16	B

Figure 2-6: 32 and 64 DIMM Slots for CPU1–CPU4.

> **REMEMBER** The DL580 G7 uses cartridges BL680c/BL620c use DIMM slots to populate the DIMMs. All require DIMMs to be populated in pairs.

Population Rules — 4-Way AMD Servers

Thankfully, populating the 4-Way AMD servers is fairly straightforward. You install them just like the 2P servers discussed earlier in the "Population Rules — AMD Opteron 6100 series servers" section, except there are twice as many processors.

For BL685 G7 servers with 32 slots:

> ✔ There are two DIMM slots for each memory channel; 4 channels per CPU; 32 total slots (on a four CPU server)

For DL585 G7 servers with 48 slots:

> ✔ There are three DIMM slots for each memory channel; 4 channels per CPU; 48 total slots (four CPU server)

Much more information is available via the HP DDR3 online configuration tool at www.hp.com/go/ ddr3memory-configurator.

Part III

Ten Common Questions about DDR3

. . . .

In This Part

▶ Figuring out what DDR3 is

▶ Deciding between RDIMM and UDIMM

▶ Knowing what mistakes to avoid

. . . .

*T*he Top Ten part is a *For Dummies* tradition. In this part, we answer some of your most pressing questions. All the wisdom you need, in a nutshell.

There's Nothing about Music at All — What Gives?

You're looking for a book about Dance Dance Revolution. A different kind of DDR!

What Is DDR3 Memory?

DDR is a form of SDRAM (synchronous dynamic random access memory), *dynamic* meaning it forgets what's stored when you pull the power plug, unlike ROM or firmware.

What Does the 3 Stand For? And What's the Big Deal?

This is the third iteration of double data rate memory, each twice as fast (data transfer rate) as the previous. Before there was DDR2 there was DDR, which some now call DDR1. The primary benefit of DDR3 memory lies in its ability to transfer I/O data at eight times the data rate of the memory cells it contains.

How Many Kinds of DDR3 Memory Are There?

Two major kinds, with various speed and voltage options. There's RDIMM (registered DIMM) in 2GB, 4GB, 8GB, 16GB, and 32GB modules. UDIMM (unregistered DIMM, sometimes called unbuffered DIMM) comes in 1GB, 2GB, and 4GB modules. There are versions running at 1333, 1067, and 800 MHz. The first RDIMMs worked at 1.5V, with 1.35V added later. The standard allows for individual DDR3 chips of 512Mb to 8Gb, which translates to modules of up to 32GB.

LRDIMM (load reduced DIMM) is really a third kind of niche memory geared toward high density memory modules for customers who want the absolute maximum memory footprint and performance. Like RDIMMs versus UDIMMs, you can't mix LRDIMMs with either RDIMMs or UDIMMs.

Which Do I Want, RDIMM or UDIMM?

RDIMM is your choice for capacity (up to 384GB in a qualified 18-slot Intel server) and advanced ECC (error correction) support. UDIMM is suitable for smaller-capacity needs (up to 48GB in a 12-slot Intel server) with lower price points. Basically: big server, RDIMM; entry server, UDIMM; not sure, RDIMM.

Is RDIMM or UDIMM Greener?

Both use lower voltage and thus less power than DDR2. DDR2 operated at 1.8 volts. DDR3 runs at 1.5 volts and 1.35 volts. The power savings between DDR2 and DDR3 amounts to about 30 percent fewer watts consumed, and it's more than just the mathematical difference between 1.8 and 1.5 volts. And the difference between DDR3 standard versus low voltage is another 15 to 20 percent power savings, which can really add up for larger data centers. Between RDIMM and UDIMM, UDIMM uses a bit less power because it has no register chip.

Which Works in Which HP ProLiant G6 and G7 Server?

RDIMM works in all HP servers, except for the ML110 and MicroServer, which are limited to UDIMM.

How Else Could I Mess Up?

You can't mix and match RDIMMs and UDIMMs in the same machine. In some cases you can't install single DIMM banks. UDIMMs must be ECC (error correcting code) UDIMMs, although when you configure through HP, the only UDIMM configurations you'll see will be ECC UDIMMs. And you can't use DDR2 memory in ProLiant Intel 55XX G6 platform servers: DDR2 doesn't fit because of lockout notch, first of all, and if by some brute-force quirk you were to seat the memory without breaking something (you can't), there would be techno-logical differences.

Is There a DDR4?

You had to ask! DDR memory evolves in cycles of two to four years, so you might expect a DDR4 technology early in the next few years. But it's not out now and shouldn't affect current planning and implementation. DDR3 will last well into the next-generation HP ProLiant servers.

Why Should I Buy DDR3 Memory from HP?

It's possible to find DDR3 RAM from sources other than HP. Being the largest buyer of DRAM on the planet, HP has the ability to choose and qualify only the highest-quality DRAM. The memory HP rejects doesn't get scrapped but instead, gets resold to other OEMs and third party module manufacturers. HP Memory is tested, tuned, and optimized on HP ProLiant branded servers, not just test equipment. This ensures utmost reliability and reduces memory errors related to board level signal integrity issues. HP stands behind the memory it recommends and sells. It can take on the warranty of the server attached for up to three years. If there's a performance issue, you don't suffer from multiple-vendor finger pointing. For more information on HP Qualified Server Memory or other HP Qualified Options visit `www.hp.com/go/hpqo`.

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