

HP ProLiant Intel-based 300-series G6 and G7 servers

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Abstract

This technology brief describes the key technologies implemented in Intel-based HP ProLiant 300-series G6 and G7 servers. As of this writing, the Intel-based ProLiant 300-series G6 servers include the DL320, ML330, ML350, and ML/DL370 servers. The Intel-based 300-series G7 servers include the DL360 and DL380 servers. For detailed information about these servers, refer to the QuickSpec links listed at the end of this technology brief.

Introduction

HP ProLiant 300-series servers have been the focus of extensive engineering and development. These Intel-based G6 and G7 servers are characterized by increased performance, better power efficiency, and more powerful management tools. Several key technologies are included:

- The Intel® Xeon® Processor 5500 and 5600 Series
- Double Data Rate-3 (DDR3) DIMMs
- Thermal sensors incorporated throughout the ProLiant 300-series G6 and G7 servers
- Integrated Lights-Out 2 and 3 (iLO 2, iLO 3) that deliver power and temperature management through multiple sensors and fan control
- Dynamic Power Capping that limits peak power consumption without risk of overloading data center branch circuits
- I/O technologies such as PCIe generation 2 (PCIe 2.0) and faster Smart Array controllers that incorporate common form factor components
- B110i software RAID with support for Hot Plug drives in the embedded SATA controller
- Flash-backed write cache for Smart Array controllers
- Common Slot power supplies to provide the required amount of power and improve power efficiency

The technologies discussed in this paper are implemented in all Intel-based ProLiant 300-series G6 and G7 servers. Exceptions are noted where different levels of technology implementation or service exist among individual ProLiant 300-series platforms.

For complete specifications of all ProLiant 300-series servers, see the HP website:
www.hp.com/products/servers/platforms.

HP servers and balanced architecture

HP designs cost-competitive, power-efficient servers that use a balanced architecture to address performance requirements and provide value.

HP servers achieve a balanced architecture through superior engineering of fundamental elements such as mechanical infrastructure, power, cooling, processor, memory, I/O devices, storage, boot, networking, and interconnecting components. A balanced architecture includes the following:

- Compute capability, processor core count, cache size per processor, and processor socket count
- Low-latency processor-to-memory bandwidth commensurate with core count
- Memory footprint and capacity that maximizes bandwidth and capacity with power efficiency and performance without compromising quality or reliability
- Application-appropriate IO devices
- Closely-coupled and balanced processor-to-memory and processor-to-I/O ratios

- Mechanical design that ensures optimum levels of cooling, stability, and serviceability through space-efficient, modular partitioning across the server

By designing a balanced architecture, HP ensures that all subsystems can be used effectively under a broad range of applications and workloads. For example, increasing memory capacity asymmetrically will not increase performance as effectively as distributing the same amount of memory across processors and IO devices. Inefficient memory distribution yields diminishing returns on power consumption and cost. A virtual machine (VM), for example, benefits from memory closely coupled to the processor responsible for that VM. Furthermore, a server needs to have appropriate levels of I/O bandwidth and CPU capabilities to ensure that memory can be used effectively by every VM.

Intel Xeon 5500 Series processor technology

ProLiant Intel-based 300-series G6 servers contain the Xeon 5500 Series processors. The Xeon 5500 Series microarchitecture is built on hafnium-based, 45 nanometer, high-k metal gate silicon technology. Xeon 5500 Series processors use a new material combination of high-k gate dielectrics and conductors which reduce electrical leakage—enabling smaller, more energy-efficient, and higher performance processors. The processors support distributed shared memory, simultaneous multi-threading, Turbo Boost, and dynamic power management.¹

Multi-level caches

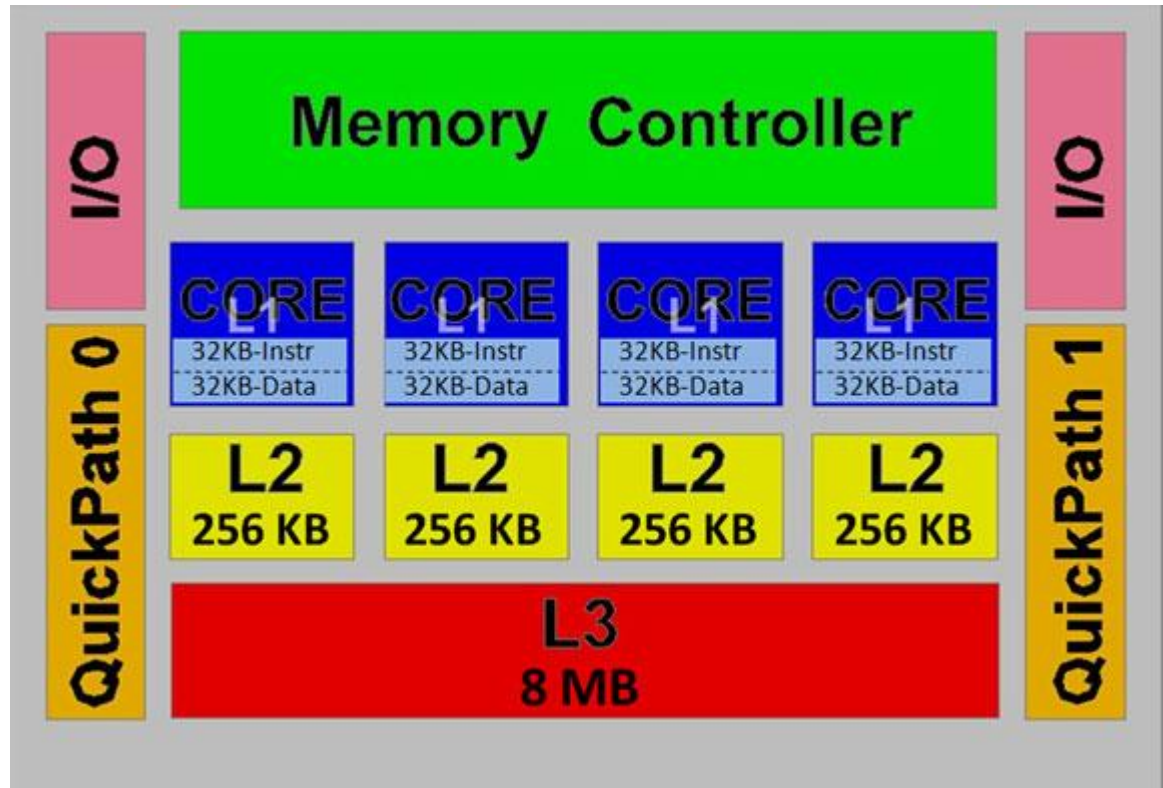
Xeon 5500 Series processors have a three-level cache hierarchy (Figure 1):

- An on-core 64-kB Level 1 cache, split into two 32 kB caches: one for data and one for instructions
- 256-kB, Level 2 cache for each core to reduce latency
- A Level 3 cache of up to 8 MB shared by all cores

¹ For additional information about Intel processors, see the HP technology brief titled “AMD Opteron™ and Intel® Xeon® x86 processors in industry-standard servers”:

<http://h20000.www2.hp.com/bc/docs/support/SupportManual/C02731435/C02731435.pdf>.

Figure 1: Block diagram of three-level cache hierarchy for Intel Xeon 5500 Series processors



The Level 3 cache is shared and inclusive, which means that it duplicates the data stored in the Level 1 and Level 2 caches of each core. This guarantees that data is stored outside the cores and minimizes latency by eliminating unnecessary core snoops to the Level 1 and Level 2 caches. Flags in the Level 3 cache track which core's cache supplied the original data. Therefore, if one core modifies another core's data in Level 3 cache, the Level 1 and Level 2 caches are updated as well. This eliminates excessive inter-core traffic and ensures multi-level cache coherency.

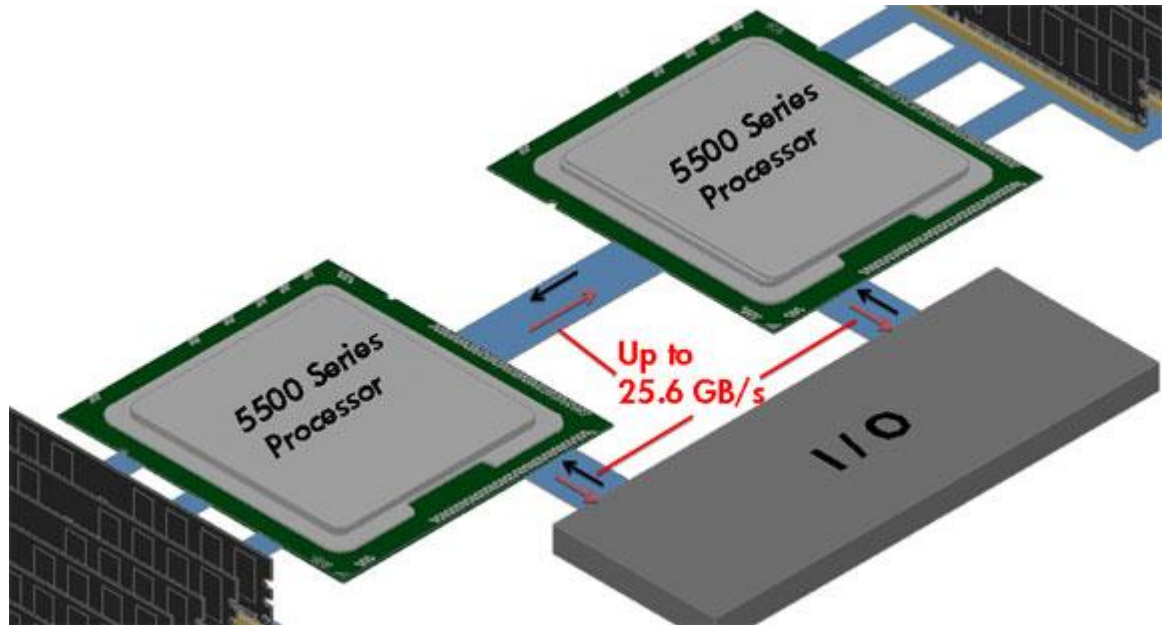
Integrated memory controller

Instead of sharing a single pool of system memory, each processor accesses its own dedicated DDR3 system memory directly through an integrated memory controller. Three memory channels from each memory controller to its dedicated memory provide a total bandwidth of 32 GB/s. The three memory channels eliminate the bottleneck associated with earlier processor architectures in which all system memory access took place through a single memory controller over the front side bus. When one processor needs to access the memory of another processor, it can do so through the QuickPath Interconnect.

QuickPath Interconnect controller

Xeon 5500 Series processors include the Intel QuickPath Architecture (Figure 2); high-speed, point-to-point interconnects directly connect the processors. The Intel QuickPath Architecture also connects each processor to distributed shared memory and to the I/O chipset. The interconnect performs a maximum of 6.4 gigatransfers per second and has a bandwidth of 12.8-GB/s in each direction, for a total bandwidth of 25.6 GB/s.

Figure 2: Block diagram of QuickPath architecture



Hyper Threading

Hyper-Threading improves performance per watt, allowing Intel-based ProLiant G6 and G7 servers to accomplish more using the same, or less, power than servers based on previous-generation Intel processors. Simultaneous Multi-threading Technology, or SMT, is an enhanced version of Intel's Hyper-Threading Technology. SMT lets each core execute two computational threads at the same time. A single processor can execute up to eight threads simultaneously. Compared to the previous Intel core architecture, the high-bandwidth memory subsystem supplies data faster to the two computational processes, and the low-latency cache hierarchy allows more instructions to be processed simultaneously.

Turbo Boost technology

Intel's Turbo Boost technology complements SMT by increasing the performance of both multi-threaded and single-threaded workloads. If your workloads and applications are not multi-threaded, Turbo Boost technology can provide better performance. Turbo Boost is engaged by default and automatically increases the clock frequency of active cores operating below power and thermal design points determined by the processor. The maximum frequency depends on the number of active cores and varies based on the specific configuration on a per-processor-number basis. Turbo Boost technology is OS independent, which means that Advanced Configuration and Power Interface-aware (ACPI) operating systems require no changes to support Turbo Boost technology.

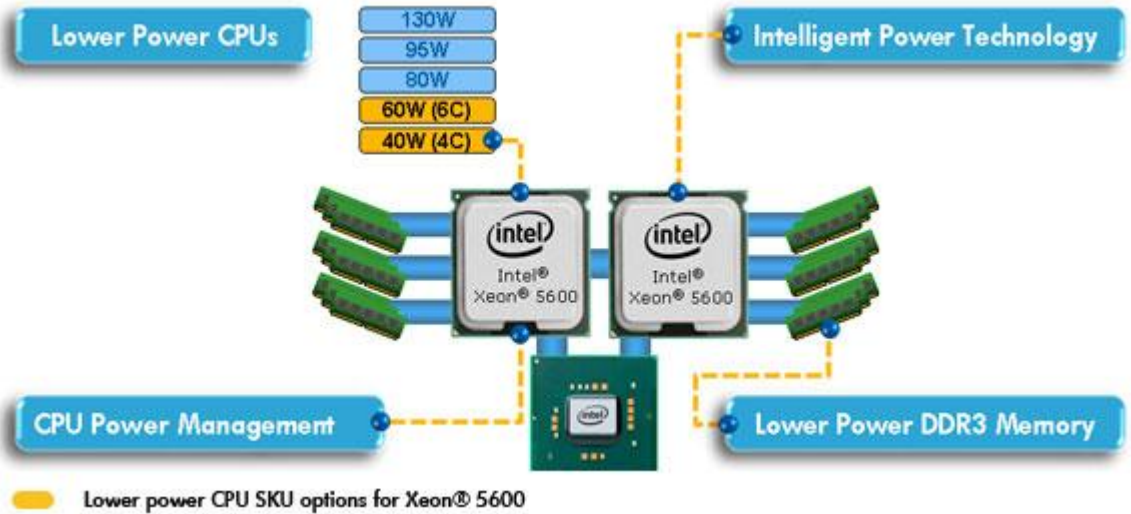
Intel Xeon 5600 Series processor technology

ProLiant Intel 300-series G7 and some G6 servers use the Intel Xeon 5600 series processor. As Figure 3 shows, the Intel Xeon 5600 Series processor uses the same microarchitecture as the Xeon 5500 Series processor; it uses 32 nanometer process technology. The 5600 uses faster and lower power second-generation high-k + metal gate transistors to produce high-performance processors that require less power. It achieves up to 45% better performance per Watt over the Xeon 5500 Series

processor (Xeon 5670 compared to Xeon 5570). Compared to the 5500 Series processor, the 5600 Series offers a smaller processor core size, new microcode instructions to accelerate encryption and decryption algorithms, and new hardware features to improve power management capabilities.

The Xeon 5600 Series processor shown in Figure 3 offers 4- and 6-core processor models with a shared cache of up to 12 MB. In addition to Intel QuickPath Interconnect and Hyper-Threading technologies, the 5600 provides more efficient Turbo Boost and memory power management, improved Intelligent Power Technology (Integrated Power Gates and Automated Low Power States) with six cores, and Low-voltage DDR3 support.

Figure 3: Intel Xeon 5600 series processor and chipset architecture



Advanced Encryption Standard New Instructions

Advanced Encryption Standard New Instructions (AES-NI) is a set of six new instructions in the Intel 5600 Series processor architecture that is designed to consolidate the AES mathematical operations and improve encryption performance. For applications using the AES algorithm, AES-NI speeds up the encryption algorithms up to tenfold. This allows IT departments to deploy data encryption not previously feasible due to performance concerns. Examples include AES-NI optimized SSL and IPsec for protecting data in transit, and full-disk encryption or database encryption to protect data at rest.

Memory technologies

The Xeon 5500 and 5600 Series processors connect directly to memory rather than through a chipset. They support only DDR3 DIMMs. HP designed the 300-series servers so that you can manage all memory options through the server Basic Input/Output System (BIOS) and ROM Based Setup Utility (RBSU). HP designed specific BIOS and RBSU functions to manage memory configurations, letting you optimize configurations for maximum performance while reducing power consumption and cooling requirements. You can also manage memory protection and latency reduction options. Because of the increased reliability of DDR3 on-DIMM thermal sensors, HP incorporates DIMM thermal data into the algorithms controlling thermal and power states within the server.

DDR3

DDR3 has several key enhancements including an 8-bit prefetch buffer for storing data before it is requested. By comparison, DDR-2 has a 4-bit buffer. For DDR3, the data signal rate can increase to 1333 Megatransfers per second (MT/s). While this is commonly referred to as having a speed of 1333 MHz, the maximum clock speed for the DIMMs is actually 667 MHz and the signal is double-pumped to achieve the 1333 MT/s data rate. DDR3-1333 DIMMs can operate at clock speeds of 667 MHz, 533 MHz and 400 MHz; with corresponding data rates of 1333, 1066, and 800 MT/s. The three memory channels between the processor's integrated memory controller and the dedicated DDR3 memory provide a total bandwidth of 32 GB/s.

On-DIMM thermal sensors

HP DDR3 DIMM modules incorporate an integrated thermal sensor that signals the chipset to throttle memory traffic to the DIMM if its temperature exceeds a programmable critical trip point. By using the data from these thermal sensors, HP has engineered ProLiant G6 and G7 servers to reduce fan speed when memory is idle, effectively reducing power consumption. The BIOS in ProLiant G6 and G7 servers verifies the presence of the thermal DIMM sensor during POST. Some third-party DIMMs may not include this thermal sensor. If it is absent, a POST message will warn that the DIMM does not have a thermal sensor, and the fans will be forced to run at higher speeds (requiring more power).

DIMM choices

DDR3 is available as both Unbuffered Dual In-line Memory Modules (UDIMMs) and Registered (buffered) Dual In-line Memory Modules (RDIMMs). Both RDIMMs and UDIMMs support error correcting code (ECC).

There are three types of DDR3 available for ProLiant G6 servers:

- PC3-8500R (RDIMM, ECC compliant) — 1066 or 800 MT/s data rate, depending on memory configuration and processor installed.
- PC3-10600E (UDIMM, ECC compliant) — 1333, 1066, or 800 MT/s data rate, depending on memory configuration and processor installed.
- PC3-10600R (RDIMM, ECC compliant) — 1333, 1066, or 800 MT/s data rate, depending on memory configuration and processor installed.

Low-voltage DDR3

Customers can take advantage of the HP low voltage (LV) DDR3 memory option. LV memory can operate at 1.35 V, reducing power and cooling requirements. Some LV DIMM configurations can affect performance. The difference occurs in 2 DIMM per channel (DPC) configurations with dual-rank DIMMs. In these configurations, the memory bus runs at 1.5 V with 2 DPC at 1333 MT/s, or 1.35 V with 2 DPC at 1066 MT/s. This results in a 20% reduction in bandwidth for the lower voltage. In all other HP LV configurations, the LV data rate is the standard 1.5V data rate. The BIOS determines the DIMM population from the system and the operating voltage and data rate capability from the DIMMs. The BIOS then sets the data rate based on that information.

NOTE:

Although the bandwidth reduction from DDR3-1333 to DDR3-1066 is 20%, the measured reduction in throughput is 10%

Single rank DIMMs configured at 1, 2, and 3 DPC; and dual rank DIMMs configured at 1 and 3 DPC run at the 1333 MT/s data rate at both voltages.

ProLiant G6 and G7 server models with the Intel 5600 Series processor support LV memory:

- PC3L-10600R—1333 1066 or 800 MT/s data rate, depending on memory configuration.

DIMM configuration guidelines

Administrators can configure ProLiant 300-series G6 and G7 servers using either RDIMMs or UDIMMs, although RDIMM and UDIMM memory cannot be mixed within a single server. ProLiant 300-series G6 and G7 servers have up to 18 DIMM slots, allowing larger memory capacities than with the platforms that used DDR-2. These servers optimize memory performance by operating DDR3 memory at the maximum rate possible, based on the memory configuration and processor installed.

When choosing memory configurations for 300-series G6 and G7 systems, the following guidelines should prove helpful:

- UDIMM configurations are limited to a maximum of two UDIMMs per memory channel because the memory controller must drive the address and command signals to each DRAM chip on a channel. This results in a 24 GB maximum configuration in ProLiant 300-series G6 and G7 servers. Because they require fewer components, UDIMMs are typically less expensive than RDIMMs.
- RDIMM configurations can provide larger memory capacity configuration because the memory controller only drives the address and command signals to a single register chip, thereby reducing the electrical load on the memory controller. Users requiring large memory footprints can install Quad-Rank RDIMMs for a total of 192 GB.
- For smaller memory configurations, installing only one or two DIMMs per memory channel can potentially increase memory performance. In many instances this allows administrators to clock the memory channel at a higher data rate.
- Quad-rank DIMMs support up to 2 DIMMs per channel
- Low voltage DIMMs can provide up to 10% DIMM power savings. Low- and standard-voltage DIMMS are compatible; systems automatically adjust voltage based on DIMMs installed.
- Processor SKU determines the ability of ProLiant G6 and G7 servers to run DDR3 memory at a top speed of 1333 MT/s. The processor SKU also dictates the range of speeds possible in different DIMM per channel (DPC) configurations. DIMM operating speeds are also subject to the number and configuration of memory slots in the server in question. Only HP branded DIMMS have been fully validated to operate at 1333 MT/s data rates with two DIMMs per channel. Therefore, HP does not recommend this configuration when using third-party DIMMs because they may not meet HP's stringent design requirements.

NOTE:

DDR3 DIMM speeds will vary depending on number of DIMMs per channel. Consult the server QuickSpec to determine DIMM speeds for given configurations.

For help configuring DDR3 memory in ProLiant G6 and G7 servers, use the DDR3 Memory Configuration Tool found at <http://www.hp.com/go/ddr3memoryconfigurator>.

Memory Mirroring with DDR3

ProLiant 300-series G6 and G7 servers using the Xeon 5500 and 5600 processors are designed to use memory mirroring which protects the system against uncorrectable memory errors that would otherwise result in a system hang or crash. Mirroring occurs when all data is written to both sets of physical memory in channels one and two. Administrators can configure memory mirroring through RBSU. To implement mirroring with DDR3, the two memory channels must be populated identically. The third memory channel must be empty.

If an uncorrectable error occurs, the system automatically directs the read to the mirrored location to obtain the correct data. Since each mirrored DIMM is one of a pair, one DIMM can be protected by mirroring while another is degraded. As a result, even after mirroring is degraded by a DIMM failure, the other DIMM in the mirrored pair is still protected by Advanced ECC. The OS does not revert to Advanced ECC Mode until the failed DIMM is replaced and the server rebooted.

Memory channel interleaving

Xeon 5500, and 5600 Series processors retrieve data from the memory DIMMs in 64-byte chunks. With channel interleaving, the system is set up so that each consecutive 64-byte chunk in the memory map is physically transferred by means of alternate routing through the three available data channels.

The result is that when the memory controller needs to access a block of logically contiguous memory, the requests are distributed more evenly across the three channels rather than potentially stacking up in the request queue of a single channel. This alternate routing decreases memory access latency and increases performance. However, interleaving memory channels increases the probability that more DIMMs need to be kept in an active state (requiring more power) since the memory controller alternates between channels and between DIMMs. This is discussed further in the “Power and thermal technologies” section.

Lockstep memory mode

Lockstep mode is an advanced memory protection feature supported in ProLiant Intel 300-series G6 and G7 servers using the Xeon 5500 and 5600 Series processors. It uses two of the processor's three memory channels to provide an even higher level of protection than Advanced ECC. In lockstep mode, two channels operate as a single channel—each write and read operation moves a data word two channels wide. The cache line is split across both channels to provide 2x 8-bit error detection and 8-bit error correction within a single DRAM. In three-channel memory systems, the third channel is unused and left unpopulated. The Lockstep Memory mode is the most reliable memory protection method, but it reduces the total system memory capacity by a third in most systems. Performance is measurably slower than normal Advanced ECC mode, and uncorrectable memory errors can only be isolated to a pair of DIMMs instead of a single DIMM. Lockstep mode is not the default operation; administrators must enable it in RBSU.

Online memory spare mode

HP designed the ProLiant 300 series G6 and G7 servers using the Intel 5600 series processors to allow online memory spares. In online spare mode, a populated memory channel is designated as the spare, which makes it unavailable for normal use as system memory. If a system memory DIMM exceeds a threshold rate of correctable memory errors, the affected channel is taken offline and the data is copied to the spare channel. This capability maintains server availability and memory reliability without service intervention or server interruption. The DIMM that exceeded the error threshold can be replaced at the administrator's convenience during a scheduled shutdown.

Of the three available channels (channels zero, one, and two) per memory controller, two channels (channels zero and one) operate normally and the remaining channel (channel two) is designated as the spare. To implement online spare mode, all three channels must be populated identically.

The system BIOS controls online spare mode; it does not require OS support or special software. However, to support messaging and logging at the console along with messages in HP Systems Insight Manager, the OS must have system management and agent support for Advanced Memory Protection. Implementing Online Spare mode over Advanced ECC requires extra DIMMs for the spare memory channel and reduces the memory capacity of the system. Once the online spare is used, the system drops to Advanced ECC protection until a scheduled shutdown when the faulty DIMM can be replaced.

NOTE:

Online Spare memory reduces the chance of an uncorrectable error bringing down the system; however, it does not fully protect the system against uncorrectable memory errors.

For additional information about DDR3 memory, see the paper titled “Memory technology evolution: an overview of system memory technologies” at

<http://h20000.www2.hp.com/bc/docs/support/SupportManual/c00256987/c00256987.pdf>.

I/O technologies

ProLiant 300-series G6 and G7 servers incorporate PCI Express, Serial-Attached SCSI (SAS), and Serial ATA (SATA) I/O technologies. PCI Express lets administrators add expansion cards with various capabilities to the system. SAS is a serial communication protocol for direct attached storage devices such as SAS and SATA hard drives.

PCI Express technology

All ProLiant G6 and G7 servers support the PCIe 2.0 specification. PCIe 2.0 has a per-lane signaling rate of 5 Gb/s—double the per-lane signaling rate of PCIe 1.0.

PCIe 2.0 is completely backward compatible with PCIe 1.0. A PCIe 2.0 device can be used in a PCIe 1.0 slot and a PCIe 1.0 device can be used in a PCIe 2.0 slot. Table 1 shows the level of interoperability between PCIe cards and PCIe slots.

Table 1. PCIe device interoperability

PCIe device type	x4 Connector x4 Link	x8 Connector x4 Link	x8 Connector x8 Link	x16 Connector x8 Link	x16 Connector x16 Link
x4 card	x4 operation	x4 operation	x4 operation	x4 operation	x4 operation
x8 card	Not allowed	x4 operation	x8 operation	x8 operation	x8 operation
x16 card	Not allowed	Not allowed	Not allowed	x8 operation	x16 operation

HP Smart Array and SAS/SATA technology

The newest serial PCIe 2.0-capable Smart Array controllers use Serial Attached SCSI (SAS) technology, a point-to-point architecture in which each device connects directly to a SAS port rather than sharing a common bus as with parallel SCSI devices. Point-to-point links increase data throughput and improve the ability to locate and fix disk failures. More importantly, SAS architecture solves the parallel SCSI problems of clock skew and signal degradation at higher signaling rates.²

The latest Smart Array controllers are compatible with Serial Advanced Technology Attachment (SATA) technology and include the following features to enhance performance and maintain data availability and reliability:

² For more information about SAS technology, refer to the HP technology brief titled “Serial Attached SCSI storage technology” available at <http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01613420/c01613420.pdf>.

- SAS and SATA compatibility — SAS-2 compliance lets administrators deploy and manage both SAS arrays and SATA arrays. Smart Array configuration utilities help administrators configure arrays correctly so that data remains available and reliable.
- SAS wide port operations — Wide ports contain four single lane (1x) SAS connectors and the cabling bundles all four lanes together. SAS wide ports enhance performance by balancing SAS traffic across the links. In addition, wide ports provide redundancy by tolerating up to three physical link failures while maintaining the ability to communicate with the disk drives. The tolerance for link failures is possible because wide port connections are established from Phy³ to Phy, and multiple, simultaneous connections to different destinations are possible. The most common use of these wide links is to a JBOD or to an internal server expander connecting to large numbers of drives. No special configuration is required for this functionality.
- SAS expanders — Low-cost, high-speed switches called expanders can combine multiple single links to create wide ports and increase available bandwidth. SAS expander devices also offer higher system performance by expanding the number of hard drives that can be attached to an HP Smart Array controller. SAS expanders are an aggregation point for large numbers of drives or servers providing a common connection. By cascading expanders, administrators can chain multiple storage boxes together. For more information on the HP SAS Expander Card, go to <http://h18004.www1.hp.com/products/servers/proliantstorage/arraycontrollers/sas-expander/index.html>.

SAS-2

SAS-2 and PCIe 2.0 are among the technologies responsible for a significant increase in performance over past generations of Smart Array controllers. The second-generation SAS (SAS-2) link speed⁴ of 6 Gb/s is double the SAS-1 transfer rate. Operation at SAS-2 link speeds requires SAS-2 compliant hard drives. SAS-2 eliminates the distinction between fanout and edge expanders by replacing them with self-configuring expanders. SAS-2 enables zoning for enhanced resource deployment, flexibility, security, and data traffic management. SAS-2 is also backward compatible with SAS-1.

Beginning with HP product releases in the first quarter of 2009, Smart Array controllers are SAS-2 capable. In fully supported controllers, 6-Gb/s SAS technology allows Smart Array controllers to deliver peak data bandwidth up to 600 MB/s per physical link in each direction. SAS devices are capable of sending and receiving data simultaneously across each physical link (full duplex mode). When running full duplex, 6-Gb/s SAS technology can deliver peak data bandwidth up to 1200 MB/s.

The SAS-2 specification is compatible with both Serial SCSI and Serial ATA protocols for communicating commands to SAS and SATA devices. SAS-2 compliant controllers are fully compatible with 1.5-Gb/s and 3.0-Gb/s SATA technology.

For an up-to-date listing of HP Smart Array controllers that support the SAS-2 specification, see the Smart Array controller matrix: www.hp.com/products/smartarray

HP Smart Array controllers based on PCIe 2.0

The Smart Array PCIe 2.0-based controllers are modular solutions with a common form factor, hardware, and firmware. Any of the ProLiant 300-series G6 and G7 servers can use PCIe 2.0-based controllers. With the exception of the DL320 G6 and ML330 G6 servers, the ProLiant 300-series G6 and G7 servers incorporate embedded HP Smart Array P410i/Zero Memory Controllers (RAID 0/1/1+0). As a standard entry level RAID, HP designed the Smart Array 410i with a unique Zero Memory RAID (ZMR) capability. Administrators can choose the cache size and can choose to include

³ The mechanism that contains a transceiver which electrically interfaces to a physical link. Phy is a common abbreviation for the physical layer of the OSI model.

⁴ The Serial Attached SCSI - 2 (SAS-2 or SAS 2.0) is a draft standard, and is the product of the Technical Committee 10t Organization. SAS 2.0 is second generation of SAS and is based upon SAS - 1.1. The SAS-2 specification is available from the 10t website, <http://www.t10.org>.

either the battery backed write cache (BBWC), or the Flash-backed write cache (FBWC). These options allow users to upgrade from ZMR to 512 MB with the BBWC and up to 1 GB with the FBWC (this upgrade is included as a standard capability with some 300-series G6 and G7 servers).

Battery backed write cache

The BBWC system continues to be an option for capacity expansion (adding one or more physical disks to an existing array). The Smart Array controller recalculates parity and balances the data across all the disks. During the expansion, the BBWC preserves data and logical structures on the array. The HP 650 mAh P-Series battery extends battery life up to 48 hours before recharging becomes necessary.

NOTE:

The P212 controller can only be upgraded to 256 MB BBWC and does not support 512 MB BBWC.

Flash-backed write cache

HP introduced the flash-backed write-cache (FBWC) system in the fourth quarter of 2009. The FBWC uses NAND⁵ flash devices to retain cache data and super-capacitors (Super-caps) instead of batteries to provide power during a power loss. The FBWC offers significant advantages over the HP Battery-backed write-cache (BBWC) system. Since the FBWC writes the contents of memory to flash devices, there is no longer a 48-hour battery life limitation and the data will be posted to the disk drive on the next power up.

The FBWC DDR2 mini-DIMM cache module is specifically designed for the present generation of PCIe2.0, SAS-based Smart Array controllers based on the PMC PM8011 SAS SRC 8x6G RAID on a chip (RoC). The primary FBWC components consist of the cache module, Super-caps with integrated charger, and RoC located on the system board.

At the time of this writing, the FBWC cache is supported on the Smart Array P410, P410i, P411, P212, P812, and P712m.

For more information on the flash-backed write cache, see the "HP Smart Array Controller technology brief" at

<http://h20000.www2.hp.com/bc/docs/support/SupportManual/c00687518/c00687518.pdf>

Zero Memory RAID

Using Zero Memory RAID (ZMR), administrators can create a RAID 0-1 configuration without using any additional memory. Smart Array P410, P410i, P411, and P212 controllers include ZMR. The P212 controller does not include ZMR on the external connector. ZMR supports up to eight drives in Zero Memory Mode, or seven drives and one tape drive. Modular Smart Array (MSA) products are not supported in ZMR mode. ZMR does not include any caching. All systems can be upgraded to a BBWC or FBWC memory module that can significantly increase performance.

Software RAID

HP has developed a software RAID solution based on the Smart Array firmware. The Smart Array B110i SATA Software RAID supports the Array Configuration Utility (ACU), ACU-CLI (command line interface), Simple Network Management Protocol (SNMP) agents, and Web-Based Enterprise Management (WBEM) providers.

⁵ Non-volatile semiconductor memory that can be electronically erased and reprogrammed. No power is needed to maintain data stored in the chip

The B110i features an OS-specific driver from HP that uses the embedded ICH10R controller. It can use RAID 0, 1, and 1+0 and supports a maximum of two logical drives. The B110i supports up to four 1.5Gb or 3Gb SATA drives. Because it is based on the Smart Array firmware, you can migrate drives to a hardware-based Smart Array controller in a seamless procedure that maintains the user data and RAID configuration.

The Smart Array B110i also includes the following:

- Support for solid state disks
- LED support
- SATA drive firmware flashing (offline)

Hot Plug technology

The HP Smart Array B110i SATA Raid Hot Plug Advance Pack provides hot-plug RAID support for the embedded SATA controller. The Hot Plug Advance Pack is available as a license key on cold plug and hot plug models. The existing B110i Raid 0, 1, and 1+0 will continue to support selected G6 and G7 non-hot plug and cold plug models with no fee.⁶

The B110i SATA RAID and Hot Plug Advance Pack are supported on select Intel 300 series G6 servers. See server QuickSpecs for support information. For more information about the B110i SATA Software RAID, download the B110i user guide at <http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01706551/c01706551.pdf>

Smart Array Advanced Pack (SAAP)

HP Smart Array Advanced Pack (SAAP) is firmware that provides advanced functionality to enhance performance, reliability, and availability of data. The Smart Array Controller firmware stack supports SAAP. It can be enabled on the P212, P410, P410i, and P411 controllers.

SAAP requires a license key for activation. After activation, administrators can employ several capabilities:

- RAID 6 with Advanced Data Guarding (ADG) protects against failure of any two drives. It requires a minimum of four drives, but only two would be available.
- RAID 60 allows administrators to split the RAID storage across multiple external boxes. It is supported with a minimum of eight drives, but only four would be available.
- Advanced Capacity Expansion allows users to automate the process of migrating old drives to a new array of drives.
- Mirror Splitting and Recombining in Offline Model breaks a RAID 1 configuration into two RAID 0 configurations. This is similar to a scaled down rollback functionality which requires two disk drives.
- Drive Erase erases physical disks or logical volumes. This capability is useful to decommission, redeploy, or return hard drives.
- Video On Demand Performance Optimization decreases latency and improves video streaming.

More information about SAAP is available at www.hp.com/go/SAAP.

NOTE:

Smart Array Advanced Pack is not available on Zero Memory configurations.

⁶ Non-hot plug models cable hard drives directly from the motherboard. Cold plug models utilize a hard drive backplane but do not contain a hot plug HDD controller. These models can be upgraded to hot plug with the B110i software RAID advanced pack license, or with the introduction of a Smart Array hardware-based controller.

Solid state drives

HP has introduced the second generation of solid state drives (SSD) for ProLiant servers. These solid state drives are 3 Gb/s SATA interface in both 60GB and 120GB capacities. These drives, based on NAND Single Level Cell flash technology, are implemented as SFF and LFF hot plug devices on the HP universal drive carrier for general use across the ProLiant portfolio. They deliver higher performance, lower latency, and low power solutions when compared with traditional rotating media.

You can use the HP second generation SSDs with the present generation Smart Array controllers based on the PM8011 SRC MIPS processor on select ProLiant G6 and G7 servers. See the server QuickSpecs to confirm that SSDs are supported.

For more information on HP second generation SSDs, download the “Drive technology overview” technology brief at

<http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01071496/c01071496.pdf>

Power and thermal technologies

HP engineers have developed a robust set of power and thermal technologies and components to manage power within the ProLiant 300-series G6 and G7 servers. The following technologies improve power efficiency throughout the power delivery chain:

- Efficient power delivery
- Improved thermal sensors and fan control
- Dynamic Power Capping
- Phase shedding
- Managing processor technologies
- Managing memory technologies
- Managing I/O technologies
- Power profiles

Administrators can disable certain components and capabilities within the 300-series G6 and G7 servers or reduce capabilities to bring the components to a lower power state.

Efficient power delivery

ProLiant G6 and G7 servers use common slot, “right-size” power supplies and highly efficient DC power regulators. Common Slot power supplies are an option in those G6 platforms supporting the Common Slot architecture. Those G6 servers not supporting Common slot architecture use HP industry standard⁷ power supplies. All ProLiant 300-series G6 and G7 servers use highly efficient power supplies and DC power regulators to deliver significantly higher power efficiencies.

Common Slot power supplies

The HP Common Slot power strategy provides power supply commonality across supported ProLiant G6 and G7 servers. Three different sized common slot power supplies are available so you can choose the ones that match your power needs. “Right sizing” power supplies lets you more closely match the power supply to the server power requirements in specific environments, significantly reducing wasted power. The HP Common Slot power strategy has also reduced the number of power supply designs, which in turn reduces the number of spares you need to keep in your data center.

⁷ “Industry standard” power supplies refers to form factors, such as ATX or SSI, that are predefined within the computing industry

Power supply efficiency relates to the level of effective transfer and delivery of power through the power chain. Table 2 shows that HP power supplies have achieved efficiency ratings of up to 94%, meeting the Climate Savers Platinum requirements.

Table 2. HP power supply efficiency and Climate Savers rating

Power supply	Efficiency	Rating
460W AC	up to 92% efficiency	Climate Savers Gold
750W AC	up to 92% efficiency	Climate Savers Gold
1200W AC	up to 94% efficiency	Climate Savers Platinum
1200W 48VDC	up to 90% efficiency	Climate Savers Silver

Use the HP Power Advisor to help determine which power supplies will best meet your needs: <http://h71028.www7.hp.com/enterprise/cache/600307-0-0-121.html>.

Redundant power operation

With ProLiant G6 and G7 servers, customers can select a power supply operation mode for redundant power systems. This ROM-based setup provides the user with “High Efficiency” mode and “Balanced” mode selections. In Balanced mode, both power supplies provide power equally. This mode ensures full redundancy but can result in higher power consumption when power supplies are operating with reduced loads and lower power efficiency. The High Efficiency mode means the system will only use one power supply until system load exceeds a certain threshold. The second power supply stays online maintaining redundancy but does not supply power until needed. Either selection still provides full power redundancy.

Voltage regulation

Voltage regulators convert the 12V DC supplied from the server power supply into a variety of lower voltages used by the different system components. HP has developed voltage regulators that have higher peak efficiencies and maintain greater than 90 percent efficiency over a broad range of power requirements. The net result is about an eight percent gain in DC power efficiency, which results in almost a ten percent efficiency gain in AC input power.

These efficiency gains come with no loss in performance and require no configuration by the user.

Improved thermal sensors and fan control

The ProLiant 300-series G6 and G7 servers include numerous thermal sensors—referred to as a “sea of sensors”—are located on DIMMs, hard drives, and throughout the server. The actual number of sensors varies by server platform.

The previous generation of ProLiant servers marked a shift away from processors as the primary producers of heat in the server. As memory modules become denser, they generate more heat. To combat this, DDR3 DIMMs, as used in the ProLiant G6 and G7 servers, incorporate the first reliable on-DIMM thermal sensors.

Because hard drive thermal sensors were not directly associated with fans, the fans would often operate at high speeds to prevent hard drives from overheating. ProLiant 300-series G6 and G7 servers incorporate hard drive temperature sensors into the body of data used to determine fan speed. This requires collaboration among various pieces of firmware, including the iLO firmware, system firmware, and RAID storage controller firmware. The 300-series G6 and G7 servers have “zoned” fans that increase cooling and energy efficiencies in the server by adjusting cooling to those zones when called for by the sensors. This provides improved efficiency and better acoustics for the platform. The iLO management processor in the G6 and G7 300 series uses a sophisticated control

algorithm to set the speed for each fan zone in the system based on feedback from the appropriate temperature sensors. This allows fans to consume the minimum amount of required power.

The fan control algorithm lets ProLiant 300-series G6 and G7 servers change fan speed as the situation dictates. Prior to G6, if one fan failed in a ProLiant server, all the other fans were set to high speed to assure the server remained within thermal specifications. ProLiant 300-series G6 and G7 servers now include enough sensors to construct an accurate view of the thermal landscape within the server, allowing the sensors and the fan control algorithm to determine if fan speeds need to be increased.

HP designed an RBSU option called “increased cooling” for the ProLiant 300-series G6 and G7 servers. The user can select this option and manually drive fans to higher speeds for use during situations requiring additional cooling.

HP Dynamic Power Capping

HP Dynamic Power Capping is available on all ProLiant 300-series G6 and G7 servers. This capability allows administrators to cap power use through Systems Insight Manager or Insight Control Manager and more accurately allocate the amount of power a server will use. Dynamic Power Capping can bring a server experiencing a sudden increase in workload back under its power cap in less than one-half second, preventing any surge in power demand that could cause a typical data center circuit breaker to trip. Dynamic Power Capping has been designed and tested (at 50 degrees C and 150 percent overload) to ensure that it can prevent tripping circuit breakers that have a specified trip time of three seconds or longer.

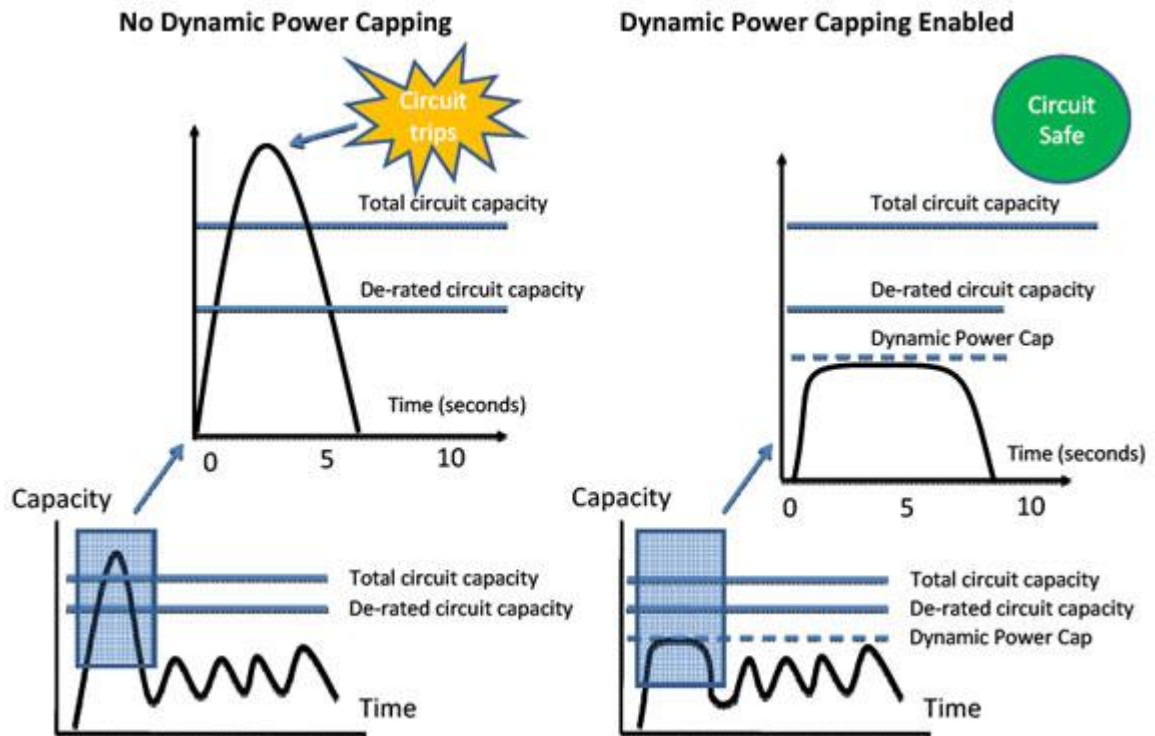
Because Dynamic Power Capping lets you keep server power consumption below a power threshold in real time, you can use it as a tool for planning and managing both electrical provisioning and cooling requirements in the data center. You can electrically provision a PDU or a rack to less than the full faceplate power rating of all the servers loaded and be assured it will not exceed the set limits.

To implement Dynamic Power Capping, the iLO management processor works in conjunction with a power microcontroller both to measure and to control power use. When enforcing the Dynamic Power Cap, the power microcontroller keeps the processor’s performance and power use under the set cap. This process is illustrated in Figure 4. You can set a Dynamic Power Cap for an individual server from the iLO Advanced user interface. For multiple rack-mount servers, you can set the Dynamic Power Caps from the power management module within HP Insight Control Environment.

HP Dynamic Power Capping is OS-independent and functions with all operating systems and software applications. HP Dynamic Power Capping will continue to function even if the software fails.

Since Dynamic Power Capping can impact server performance if set too aggressively, HP recommends that Dynamic Power Caps be set at values that match or exceed the highest observed power consumption over a representative server workload sample.

Figure 4: Intel Xeon 5600 series processor and chipset architecture



Phase shedding

HP incorporated intelligent phase shedding into ProLiant G6 and G7 voltage regulators. Modern digital voltage regulators deliver DC power using up to five different phases of high-speed power pulses that charge capacitors to deliver straight DC power to components at the proper voltage. Each phase delivers its power pulses in a rotating time window with the other phases in the voltage regulator such that the power pulses from one phase do not overlap with those of another. The width of each pulse determines the total power delivered by the particular phase.

Intelligent phase shedding lets the system BIOS turn off one or more of the power phases if it determines that the component power requirements are less than the full amount of power from the voltage regulator. This reduction in phases decreases the maximum power that the voltage regulator can deliver and increases overall efficiency.

Phase shedding based on the installed processor

The G6 and G7 server ROM configures the number of phases based on the maximum power consumption of the processor. This capability incurs no performance impact and requires no user configuration.

Memory phase shedding

Memory phase shedding operates much the same way as processor-based phase shedding. At power-up, the ROM BIOS determines the number of phases needed for the memory voltage regulator based on the number of DIMMs installed. Memory phase shedding can save up to 2.5 watts per DIMM socket. This feature is more effective on servers whose DIMM sockets are not fully populated since fewer phases are required to accommodate such a configuration. Fewer phases mean less power consumption.

Dynamic CPU phase shedding

On entry into a low power state (less than 20 W), the Intel Xeon 5500 and 5600 Series processors will activate the Power Status Indicator (PSI). When PSI is engaged, ProLiant G6 and G7 servers turn off voltage regulator phases, thereby saving power and increasing power efficiency.

Managing processor technologies

QuickPath Interconnect power

The Xeon 5500 and 5600 Series processor let the QuickPath Interconnect (QPI) buffers enter a sleep state to reduce power requirements while the QPI links are not active. HP enables this Intel feature for G6 and G7 servers through RBSU. Once this feature is enabled, the Intel processor determines when to put the QPI buffers into a sleep state. It appears that QPI power management has no measureable impact on performance.

Disabling processor cores

Through RBSU, administrators can disable one or more cores in the Xeon 5500 and 5600 Series processor (per physical processor). When enabled, the command will apply to all physical processors in the server. Engaging this capability saves power and may improve performance in servers running single workloads or applications with low requirements for threading.

Minimum processor idle power state

The Xeon 5500 and 5600 Series processors support C-states for each core within the processor. C-states define the power state of system processors and are an open specification of the ACPI group. The micro-architecture of the Xeon 5500 and 5600 Series processor supports processor C-states C0, C1, C3, and C6. C-state C0 represents a fully active core that is executing instructions. The other C-states represent increasing levels of power reduction for idle cores. Any core within the processor can change C-states independently from the other cores.

Parameters for the maximum C-state allowed for an idle processor are set through the RBSU and initiated by the OS. The higher the C-state allowed at idle, the more power savings, but only at idle. Also, the higher the allowed C-state, the higher the latency involved when the core returns to activity.

Managing memory technologies

Memory channel interleaving

As described in the [memory section](#), the alternate routing used for channel interleaving decreases memory access latency and increases performance. However, memory channel interleaving increases the probability that more DIMMs must be kept in an active state since the memory controller is alternating between channels and therefore between DIMMs.

Memory interleaving is configured in the RBSU. Disabling memory channel interleaving makes access to contiguous memory addresses revert to one channel. Single-channel access degrades performance, but makes it possible for the memory controller to place less frequently accessed DIMMs into a low power state. Memory interleaving can have a negative performance effect based on the application load of the server. Administrators should perform testing in their application environments to understand the trade-off between power savings and performance.

Maximum memory data rates

The maximum memory data rate is effectively 1333 MHz for ProLiant G6 and G7 Intel platforms.⁸ Depending on the memory configuration and installed processor, the system may automatically reduce the Quick Path Interconnect speed. While the "Auto" setting (which equates to 1333 MHz) is

⁸ The memory operates in a double-pumped manner so that the effective bandwidth is double the physical clock rate of the memory. Mega-transfers/second describes the data rate.

the default setting, users have the option to manually lower the effective data rates to 1066 MHz or 800 MHz. This will save power, but may degrade performance. Administrators can configure the maximum memory data rate through the RBSU.

Managing I/O technologies

Disable PCIe 2.0

A ProLiant G6 and G7 option allows all expansion slots to run at PCIe 1.0 rather than PCIe 2.0 speed. Enabling this option saves power and provides backward compatibility with cards that may not correctly operate in PCIe 2.0 slots. Administrators can control expansion slot speed through the RBSU.

I/O Power Provisioning

I/O Power Provisioning allows the server to cut power to embedded devices that are not in use. This option is useful for customers who prefer their own storage controllers or NIC devices instead of embedded HP devices. This option saves up to 10W on the embedded storage controller, and between 2 and 6W on embedded NICs. Administrators configure I/O Power Provisioning in the RBSU.

Power profiles

In the ProLiant 300-series G6 and G7 RBSU, the HP Power Profile defines three possible configurations of some of the power features identified earlier in this section. The HP Power Profile provides a simple mechanism for users to configure the power management options of their system based on their tolerance to power versus performance without having to individually configure each option.

There are three possible settings for the HP Power Profile: Maximum Performance; Balanced Power and Performance; and Minimum Power Usage. An additional “Custom” setting is simply any combination of user settings that do not match the pre-sets for the three categories listed in Table 3.

Table 3. Power Profile settings

Power Saving Feature	Maximum Performance	Balanced Power & Performance	Minimum Power Usage
Power Regulator	Static High	Dynamic	Static low
Manage QPI power	Off	On	On
Memory Interleave	Full interleave	Full interleave	Disabled
PCIe 2.0	Enabled	Enabled	Off
Memory Speed	Auto	Auto	800 MHz
Minimum processor idle power	No C-states	C6	C6

Systems management and monitoring

HP offers management tools to program and control all aspects of the dynamic server environment. The HP iLO 2 and 3 management processors provide remote management with other core-embedded management functions to simplify setup, health monitoring, power and thermal control, and remote administration. The HP Insight Control Environment (ICE) management suite provides a foundation for deploying, managing, optimizing, and controlling the entire server environment from any location. HP

Insight Dynamics for ProLiant delivers comprehensive functions for optimizing and balancing resources and workloads in real time.

HP Integrated Lights-Out 2

iLO 2 provides core management functionality including server power control, ROM-based setup, embedded health and management logs, power consumption level, SSH and SSL support, and flexible access through a dedicated or shared network port. With ProLiant G6 servers, HP iLO 2 supports viewing configuration and status of CPU, fans, and power supplies. The iLO 2 management processor is incorporated into all ProLiant 200-series and above G6 servers.

Management capabilities can be extended with HP iLO Advanced. iLO Advanced capabilities include high performance graphical and text console, diagnostic capabilities (including automatic video footage of the server's last boot and last fault), global team collaboration for up to four users, 24-hour power measurement, and single server Dynamic Power Capping. HP Dynamic Power Capping, enabled through iLO Advanced, is available for all ProLiant ML and DL 300-series servers. For additional details, check the HP product support matrix:

<http://www.hp.com/servers/ilo/supportedservers>.

HP Integrated Lights-Out 3

The ProLiant 300-series G7 servers include the next generation of lights-out management with iLO 3. HP developed iLO 3 to improve performance, streamline the user interface, and enhance support for management standards. Like iLO 2, the iLO3 firmware can be upgraded with HP iLO Advanced for extended functionality.

The iLO 3 hardware includes a faster processor and increased flash and DDR memory for storing and executing programs. Remote console performance is up to eight times faster than iLO2—and equal to the performance of KVM and software-based remote management solutions. The remote console for Microsoft Windows in iLO 3 is built on the .NET framework using a DirectX control; the console display scales without scroll bars, supports resolutions up to 1600X1200, and supports display across multiple monitors. Users have direct access to the remote console without having to navigate through the iLO 3 web interface. An integrated Linux version provides a single java applet to support remote console, virtual media, and virtual power functionality. The faster iLO 3 processor and a USB 2.0 host connection also enable three times better virtual media performance compared to iLO 2.

The web-based graphical user interface has been updated for iLO 3 with a look and feel similar to the Onboard Administrator; it uses Javascript Object Notation (JSON) for improved handling of dynamic content.

For environments with elevated security requirements, the iLO 3 ASIC includes an AES encryption engine. AES (Advanced Encryption Standard) is an encryption standard adopted by the U.S. government (FIPS PUBS 197, <http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf>). The iLO 3 hardware-based solution provides strong AES encryption with better performance than a software-based solution. The latest generation of iLO also provides IPMI over LAN and DCMI management interfaces for environments requiring simple standards-based monitoring and control.

Not all features of iLO 2 are supported in iLO 3. For detailed information on standard and iLO Advanced licensed features, see the iLO QuickSpecs available at: www.hp.com/go/iLO.

HP Insight Control Environment

HP Insight Control Environment management suite is the infrastructure management suite that HP recommends for every HP G6 and G7 server. Insight Control Environment provides infrastructure management functions, including a complete set of lifecycle management tools.

For more information about HP Insight Control Environment management suite, go to www.hp.com/go/ice

HP Insight Dynamics for ProLiant

HP provides tools like HP Insight Dynamics for ProLiant to assist you with continuously analyzing and optimizing your data center infrastructure. HP Insight Dynamics delivers four key capabilities for HP ProLiant 300-series G6 and G7 servers:

- Continuous capacity and power planning
- Balanced physical and virtual resources
- Cost-effective availability
- Consistent infrastructure provisioning

For more information about HP Insight Dynamics, go to www.hp.com/go/insightdynamics.

Security

The Trusted Platform Module™ (TPM) and Microsoft® BitLocker® technology are supported in all ProLiant 300-series G6 and G7 servers by means of the available Trusted Platform Module option kit. The Trusted Platform Module v1.2 supported on ProLiant G6 servers is a microcontroller chip that can create, securely store, and manage artifacts such as passwords, certificates, and encryption keys that are used to authenticate the server platform. The TPM 1.2 chip provides a unique Endorsement Key (EK) and a unique Storage Root Key (SRK). It provides data encryption and uses RSA, SHA-1, and RNG cryptographic functions to provide access protection, OS level protection, and stolen disk protection.

The TPM 1.2 chip can also store platform measurements (hashes) to help ensure that the platform remains trustworthy. TPM enables Microsoft BitLocker, part of Windows® Server 2008. TPM is an option on all ProLiant 300-series G6 and G7 servers. For more information about TPM, go to www.hp.com/go/TPM

Microsoft BitLocker Drive Encryption (BitLocker) is a data protection feature available in Windows Server 2008. BitLocker uses the enhanced security capabilities of TPM version 1.2 to protect data and to ensure that a server running Windows Server 2008 has not been compromised while the system was offline.

OS support

HP performs extensive testing, qualification, and certification of the latest server operating systems on ProLiant servers to ensure maximum performance and reliability. HP resells and provides full service and support for Microsoft® Windows® operating systems, Red Hat Linux subscriptions, Novell SUSE Linux subscriptions, Citrix XenServer, and VMware hypervisors. The latest information regarding support and deployment can be found online at www.hp.com/go/ossupport.

Summary

The development and engineering efforts associated with the HP ProLiant 300-series G6 and G7 servers help users lower power costs and increase business performance with the new Xeon 5500 and 5600 Series processor technologies, Dynamic Power Capping, efficient thermal control, common power supplies, DDR3 memory, and PCIe 2.0-compliant modular Smart Array controllers. The 300-series G6 and G7 servers possess superior technology differentiation and management capabilities with iLO 3, HP Insight Control Environment management suite, and HP Insight Dynamics for ProLiant. Users also experience the ease of server deployment with SmartStart, Insight Control server deployment, and RBSU.

For more information

For additional information, refer to the resources listed below.

Resource description	Web address
DDR3 Memory Configuration Tool	http://h18004.www1.hp.com/products/servers/options/tool/hp_memorytool.html
HP Insight Control Environment	www.hp.com/go/ice
HP Network Adapters for ProLiant DL and ML Servers	http://media.hp.com/veplatform.com/content/HP_Network_Adapters_for_ProLiant_DL_Family_data_sheet_1237839147.pdf
HP Insight Management WBEM Providers	www.hp.com/go/hpwbem
HP ProLiant DL320 G6 Server series	http://h18004.www1.hp.com/products/quickspecs/13344_na/13344_na.html
HP ProLiant ML350 G6 Server series	http://h18004.www1.hp.com/products/quickspecs/13241_na/13241_na.html
HP ProLiant DL360 G7 Server series	http://h18004.www1.hp.com/products/quickspecs/13598_na/13598_na.html
HP ProLiant DL380 G7 Server series	http://h18004.www1.hp.com/products/quickspecs/13595_na/13595_na.html
HP Integrated Lights-Out product information	www.hp.com/go/ilo
HP SAS and SATA technology	www.hp.com/go/serial
HP Smart Array Advance Pack	http://h18004.www1.hp.com/products/servers/proliantstorage/arraycontrollers/smartarray-advanced/index.html
HP Smart Array controllers	www.hp.com/products/smartarray
HP SmartStart	www.hp.com/servers/smartstart
ISS Technology Communications briefs: HP Power Capping and HP Dynamic Power Capping for ProLiant servers	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01549455/c01549455.pdf
ISS Technology Communications briefs: Memory technology evolution: an overview of system memory technologies	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c00256987/c00256987.pdf
ISS Technology Communications briefs: Serial Attached SCSI storage technology brief	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01613420/c01613420.pdf

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