This paper highlights the new architectural features and performance of the AMD Opteron™ 6100 Series processor based HP ProLiant G7 Servers. It focuses on the value to the end user when applied to High Performance Computing (HPC) solutions.

Processor innovation and system architecture consolidation changed the HPC landscape over the last decade. System design motivation transitioned from government focused, research and development driven, proprietary-based operating systems and hardware to commercial driven, standards-based components, configured to meet specific customer requirements. Long term relationships between the component and systems manufacturers are essential to help provide the end-user maximum performance with the parts available. The relationship between Advanced Micro Devices, Inc. (AMD) and Hewlett-Packard (HP) balances the system components within a power envelope enabling a broad set of individual options within consistent standards. This balance helps protect the contributions of all the stake holders in the design while helping the customer to likewise balance total cost of ownership with their requirements.

The HP ProLiant G7 Server Family built on the AMD Opteron™ 6100 Series processor represents an effective balanced design providing the end-user versatility, functionality, and increased performance within the same power and density envelope as systems based on the previous generation of AMD Opteron™ processors.
One approach for increasing processor performance within a power envelope is to increase the number of processor cores per socket while reducing the processor frequency. By providing additional levels of on-chip cache and providing additional bandwidth to the rest of the system, the performance can be enhanced for many HPC users. AMD has followed this strategy with the new AMD Opteron™ 6100 Series processor, which has doubled the number of cores and improved memory management, socket connectivity, and levels of control as compared to previous generations.

Figure 1 illustrates the increased performance of the 12-core AMD Opteron™ Model 6174 over the previous generation 6-core Opteron™ Model 2435 for selected benchmarks.

![AMD Opteron™ Model 6174 (2.2GHz, 12-core)](chart)

In Figure 1 above, benchmark results compare similarly configured 2-processor servers. The base system with performance defined as 100%, is built on the six-core AMD Opteron™ Model 2435 processors running at 2.6 GHz with main memory at 800 MHz. The performance bars are the aggregated results of classes of applications run on a HP ProLiant G7 with twelve-core AMD Opteron™ Model 6174 processors running at 2.2 GHz supported by main memory at 1333 MHz. Therefore, the number of processors remains the same, the numbers of cores are doubled and the frequency of the cores reduced by 17% while the frequency of the main memory is increased 67% to balance the bandwidth demands of the larger number of cores.

That the combination of STREAM and LINPACK results continue to provide a good correlation to the performance of HPC applications is re-enforced in the results of both the engineering analysis fluid dynamic and impact simulations displayed. The CFD bar is a simple average of the public benchmarks for both ANSYS FLUENT and CD-adapco STAR-CCM+. The impact explicit bar reflects the average of the public benchmarks for both LSTC LS-DYNA® and SIMULIA Explicit. The SPEC_rate® bar is an average of the SPEC_rate® float and SPEC_rate® integer results. The three far right bars reflect combinations of multiple public data sets run with.
each of the applications: NWChem, Gaussian, and GROMACS. Across the range of tested HPC applications, the HP ProLiant G7 configuration with the AMD Opteron™ Model 6174 demonstrated substantial improvement in performance over the previous generation Model 2425.

**Memory Management**

Memory management is critical to system performance. In-core and on-chip cache memory buffers combine with improved bandwidth to balance demands of the multiple cores and allow multiple streams of instruction and data for software execution. The AMD Opteron™ 6100 Series processor is designed to increase the overall work that is carried out within a given time, power, and density. The new processor increases performance by doubling the core count per socket over the previous generation. It matches the core count increase with improved bandwidth allowing for advanced multitasking and multithreading within a single socket. The HP ProLiant G7 Server family takes advantage of the robust feature set of the AMD Opteron™ 6100 Series processors to provide the memory expandability and server attributes appropriate for a wide variety of HPC solutions, including those used by the engineer, quantitative analyst, and biochemist.

Based on the AMD Opteron™ 6100 Series processor, the HP ProLiant G7 Server family provides either registered or un-buffered DDR3 ECC memory configured to match the number of sockets, number of cores, and clock speed. The HP ProLiant G7 Server family allows for a broad selection of internal storage and networking choices as well as integrated management, energy efficiency, and density that customers expect from the HP ProLiant brand.

The effective blending of these technologies allows for high performance in an energy efficient envelope as illustrated by the specific tests included in this product overview. Further proof points are available on both AMD and HP websites listed in the conclusion.

**All Platforms are NOT Created Equal**

The AMD Opteron™ 6000 Series platform enables improved bandwidth, connectivity and processor control features that can enhance performance and help reduce total cost of ownership. Designed to accommodate not just for this newly released generation of processors, but also for future processor generations, the Opteron 6000 Series platform supports a multi-year upgrade path and provides superior system infrastructure access for multiple processor generations. Just as previous platform designs initiated multi-core systems and provided an upgrade path for multiple processor design cycles, the AMD Opteron™ 6000 Series platform will set a new standard and provide the user with future upgrade opportunities. Performance measurements noted in Figure 2 demonstrate that the infrastructure doubles memory and I/O bandwidth over previous designs¹. This performance-focused design permits more cores, access to faster memory, with more network and storage choices for the end-user. In addition, this new platform continues to enhance energy management technology and adds hardware assisted I/O to the virtualization features.

*The AMD Opteron™ 6000 Series platform for your performance requirements, today and tomorrow.*

¹. Based on quad channel DDR3-1333 for AMD Opteron™ 6100 Series processor vs. dual channel DDR2-800 for Six-Core AMD Opteron™ processor
The AMD Opteron™ 6100 Series processor is part of the legendary AMD Opteron™ processor family with comprehensive support for higher core counts. It is designed to double performance over the previous generation AMD Opteron™ processor while remaining in a similar power and thermal envelope. The processor allows for 12 or 8 cores per socket, 12 MB shared L3 cache, four HyperTransport™ technology 3 (HT3) Links providing up to 102.4 GB/s peak bandwidth, and four 72 bit wide data channels to memory for a maximum bandwidth of 42.7 GB/s per processor with DDR3-1333 memory. The processor block diagram below shows that this processor has twice the number of cores and memory channels per socket than the previous generation, which enables up to 2.5 times higher memory bandwidth and up to 50% higher DIMM capacity per core\(^2\). It also increases the coherent HyperTransport technology bandwidth for inter-socket communication. Finally, the AMD SR5690 chipset allows for up to 42 PCIe® 2.0 Lanes with 11 controllers and a x4 A-Link to the SP5100 South Bridge for up to 2.4 times higher inter-node bandwidth. As substantiated by the benchmark results documented in Figure 1, the AMD Opteron™ 6100 Series processor provides twice the cores and twice the memory bandwidth for up to twice the performance in HPC workloads.

Delivering Performance for your Solutions

Not only does the AMD Opteron™ 6100 Series processor provide more capability than previous processor generations, it also offers code portability and optimization tools through a rich network of technology partners.

---

2. STREAM memory bandwidth of 21GB/s for Six-Core AMD Opteron™ processor-based system vs. 55GB/s for AMD Opteron™ 6100 processor based system. Configuration: 2 x Six-Core AMD Opteron™ processors Model 2435 in Supermicro H8DMU+ motherboard, 16GB (8 x 2GB DDR2-800) memory, SuSE Linux® Enterprise Server 10 SP2 64-bit; 2 x AMD Opteron™ processors Model 6174 in “Dinar” reference design kit, 32GB (8 x 4GB DDR3-1333) memory, SuSE Linux® Enterprise Server 11 64-bit.
The AMD Opteron™ 6100 Series processor provides seamless binary compatibility of software executables with common virtualization offerings. Therefore existing application executables for any operating system version created since 2004 are expected to run at maximum performance without recompile or rewrite using available virtualization tools and operating systems. Many of the performance features of the AMD Opteron™ 6100 Series processor are visible to software, plus there are a number of software-based techniques for taking advantage of acceleration techniques such as vectorization in the architecture.

AMD works with a range of industry partners to help ensure that software development tools and technologies comprehend the hardware at the lowest level, supporting application tuning for outstanding performance. The tools help identify opportunities for optimization, compile AMD-optimized code, and provide a sophisticated debugging environment. Vendors provide tools that are specific to the AMD Opteron™ processor architecture, and release products to help application developers speed time to market for accelerated codes. More information on these tools and compilers can be found at [www.amd.com/developer](http://www.amd.com/developer).

**Enabling Energy Efficient Computing**

The enhanced AMD PowerNow!™ technology works with the operating system to deliver performance-on-demand capabilities that help optimize power savings. This includes Independent Dynamic Core Technology that allows frequency to be varied per core to reduce power consumed by lower utilized cores. Separate power planes for the cores and the memory controller create opportunities for power savings within the socket. Power management features also include C1E Power State (sleep) which is evoked when all the processor cores are idle; AMD CoolSpeed technology which reduces processor power when temperature thresholds are reached; and Advanced Platform Management Link (APML) which provides for remote power state monitoring, management, and optional alerts to manage processor subsystems. The HP ProLiant G7 Server family balances the processor power envelope with support for low voltage DDR3 memory. The combined feature set of HP ProLiant G7 Servers with the AMD Opteron™ 6100 Series processor provides the HPC user a performance increase over the previous generation Opteron processors while remaining in the same energy and thermal envelope.

**The HP ProLiant G7 Server Family**

Building on the features of the AMD Opteron™ 6000 Series Platform and the AMD Opteron™ 6100 Series processors, the HP ProLiant G7 Server family leverages the new features to create a rich product selection. At every point in the product line, the HP ProLiant G7 DL and SL servers provide functionality and simplicity, with the potential to deliver full return on investment in as little as two months. The HP ProLiant SL165z G7 Server is demonstrative of the family and provides an excellent blend of density and performance for HPC.

The ProLiant SL165z G7 is a 1U server with support for two AMD Opteron™ 6100 Series processors, delivering performance and flexibility. It supports from 8 GB up to 288 GB of DDR3 1333MHz (12x16GB DIMMS + 12x8GB DIMMS) memory. As a 1U Rack-Optimized Server, it supports 4 LFF Fixed SATA/SAS or HP or 8 SFF Hot Plug SAS/SATA drives or SSD with reliability and availability enhanced with embedded SATA (RAID 0/1) and SAS/SATA RAID 0/1/5 (Optional) using software or hardware Smart Array Technology unique to HP. The system is managed node by node with On Board Administrator featuring Lights Out 100, Easy Setup CD, SNMP Agents, IPMI 2.0 and TPM 1.2 standard.
The HP ProLiant G7 DL and SL rack mount servers deliver improved levels of density and energy for extreme scale out over previous HP ProLiant systems. The architecture helps customers maximize data center floor space and provide flexible configurations that fit into existing industry standard racks. The HP ProLiant SL6000 Scalable System is designed to be easily customizable, allowing the best fit for end user requirements. Web and cloud providers, HPC data centers, and enterprise customers can benefit from the scalability and customizability of the HP ProLiant SL6000 to enable business growth and competitive advantage.

Standard options for the HP ProLiant G7 Server family include the HP Smart Array and SAS/SATA technologies. Features such as battery backed write cache, zero Memory RAID, and software RAID add to the overall configuration choices for users.

Advanced Capacity Expansion (ACE) automates higher capacity migration using capacity transformation to remove logical drives by shrinking and then expanding them online. Standard drive migration and expansion remain unchanged.
The NC522SFP is a Dual Port eight lane (x8) PCI Express (PCIe) 10 Gigabit network adapter and is supported on most HP ProLiant G7 servers. The NC522SFP uses two SFP+ (Small Form-factor Pluggable) connector cages, providing connectivity in copper or fiber optic environments. For complete specifications on this and other HP network adapter products, go to www.hp.com/go/ProLiantNICs.

HP engineers have developed a robust set of power and thermal technologies, and components to manage power in HP ProLiant G7 servers. The technologies help improve power efficiency throughout the power delivery chain in several ways:

- Efficient power delivery
- Advanced thermal sensors and fan control
- Phase shedding
- Managing processor technologies
- Managing memory technologies
- Managing I/O technologies

Administrators can disable certain components and capabilities in HP ProLiant G7 servers or reduce capabilities to bring the components to a lower power state.

Common Slot power supplies are an option in those G7 platforms supporting the Common Slot architecture. All HP ProLiant G7 servers use highly efficient power supplies and DC power regulators to enable high power efficiencies. The HP G7 Common Slot power strategy provides power supply commonality across supported HP ProLiant G7 server lines. HP reduced the number of power supply designs, which reduces the number of spares the customer must keep in the data center. By incorporating “right-sizing,” these power supplies have achieved efficiency ratings of up to 94%. With the exception of the 1200W power supplies, they meet Climate Savers Platinum requirements.

Reviewing the proven performance of the design, the added benefits of having a processor in the same thermal envelope are impressive. With twice the number of cores in the same power envelope, the processor allows the overall system to provide enhanced performance for many HPC users, and all at an affordable price point.

**The HP ProLiant G7 Servers based on the AMD Opteron™ 6100 Series processors are designed to help administrators increase performance, lower power costs, and manage their server hardware more easily.**

To improve performance, the servers use AMD Opteron™ 6100 Series processor technologies with integrated memory controllers and DDR-3 memory with increased bandwidth. When combined with Smart Array controllers using serial SAS 2 technology as well as improved firmware capabilities, these adjustments provide high rates of data transfer for RAID. HP engineers improved the thermal controls and integrated the AMD Opteron™ 6100 Series processors, incorporating multiple thermal sensors and allowing customers to constrain server power according to their needs.

Using HP Common Slot power supplies is a means for customers to refine and constrain server power based on their data center requirements. ProLiant OnBoard Administrator Powered by Lights-Out 100i and the Insight Management Agents facilitate management by incorporating HP Systems Insight Manager. Servers can be easily deployed with the Easy Set-up CD and its ISO image or with the multi-server deployment capabilities for the HP ProLiant G7 servers.

Summary

The HP ProLiant G7 Server Family built on the AMD Opteron™ 6100 Series processor represents an effective balanced design providing the end-user versatility, functionality, and increased performance within the same power and density envelope as previous systems in the series.

As the relative performance shows (Figure 1), there is substantial increase across a wide range of HPC applications. The AMD Opteron™ 6000 Series platform gives the end-user improved bandwidth connectivity and processor control features that help improve performance and reduce cost of ownership. It gives the customer a multi-year upgrade path. The AMD Opteron™ 6100 Series processor architecture can improve overall server performance and enable scalable and flexible server and HPC cluster designs. The HP ProLiant G7 Servers based on the AMD Opteron™ 6100 Series processors help administrators increase performance, lower power costs, and manage their server hardware more easily.


© 2010 Advanced Micro Devices, Inc. AMD, the AMD Arrow Logo, ATI, the ATI Logo, AMD Opteron, PowerNow, and combinations thereof are trademarks of Advanced Micro Devices, Inc. © Copyright 2010 Hewlett-Packard Development Company, L.P. The information contained herein is subject to change without notice. The only warranties for HP products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. HP shall not be liable for technical or editorial errors or omissions contained herein. Other names are for informational purposes only and may be trademarks of their respective owners. All rights reserved.