WHITE PAPER

September 1998

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Workstation Marketing

Compaq Computer Corporation

Second-Generation Highly Parallel System Architecture for Compaq Professional Workstations

With the introduction of the Compaq Professional Workstation SP700, Compaq announces the second generation of its Highly Parallel System Architecture. This innovative, standards-based architecture allows the Professional Workstation to deliver uncompromising performance by increasing overall system bandwidth. This paper provides an overview of the Highly Parallel System Architecture design and highlights the new feature sets and key benefits that have been added in this next-generation release.

CONTENTS

Introduction 3
Highly Parallel System Architecture 3
Compaq Professional Workstation SP700 4
Dual Memory Controllers 4
Dual-Peer PCI Buses 6
Dual Channel SCSI Buses 7
AGP 2X Support 7
Optimized Multiprocessing Support 8
Dual Independent Bus Architecture 8
Conclusion 8

NOTICE

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Document ECG077/0998

INTRODUCTION

Compaq first introduced its innovative Highly Parallel System Architecture in 1997 with the announcement of the Compaq Professional Workstations 6000 and 8000. Based on industry standards, this unique architecture addresses the need for greater system bandwidth in the key subsystems including memory, input/output (I/O), and processor. The results achieved enable the Compaq Professional Workstation to deliver uncompromising and unparalleled performance with the Microsoft Windows NT® platform, while running today's most demand-intensive applications.

Now with the introduction of the Compaq Professional Workstation SP700, Compaq announces the second generation of its Highly Parallel System Architecture. This latest implementation provides increased memory bandwidth, as well as dual channel SCSI buses and accelerated graphics port (AGP) 2X support. This paper explains the fundamental architectural design and highlights the key benefits and new features that characterize this next-generation release. It also points out how it is different from other architectures and the performance benefits it delivers.

HIGHLY PARALLEL SYSTEM ARCHITECTURE

Compaq workstation engineers performed extensive application profiling to understand the nature of the bottlenecks inherent when running complex, resource-intensive applications, such as those found in computer-aided drafting/computer-aided engineering (CAD/CAE), Electronic Design Automation (EDA), Digital Content Creation (DCC), Geographic Information Systems (GIS), and financial analysis environments. The Highly Parallel System Architecture increases overall system bandwidth to improve performance in demanding workstation applications by using:

- **Multiple Data Paths**. Deliver a high degree of parallelism to key subsystems, such as memory and I/O. Memory and I/O requests are processed in parallel, reducing system bottlenecks and therefore delivering higher application performance.

- **Large, High-Speed Data Buses.** Wide, high-speed data pipelines increase throughput to critical subsystems, such as processor, memory, and cache, resulting in uncompromising application performance.

- **Balanced System Resources.** Critical system resources reside on separate buses to help balance throughput, improve system efficiency, and increase performance.

COMPAQ PROFESSIONAL WORKSTATION SP700

With the Compaq Professional Workstation SP700, the second generation of the Highly Parallel System Architecture is born. This new-generation design continues to address the need for greater overall system performance by utilizing dual memory controllers and dual-peer PCI buses. However, on the SP700, the original Highly Parallel System Architecture is extended by adding dual Wide-Ultra SCSI controllers, AGP support, and optimized multiprocessing support. The block diagram below depicts how these subsystems are carefully crafted into a standards-based, high-performance architecture. The following sections discuss each of these subsystems in detail.

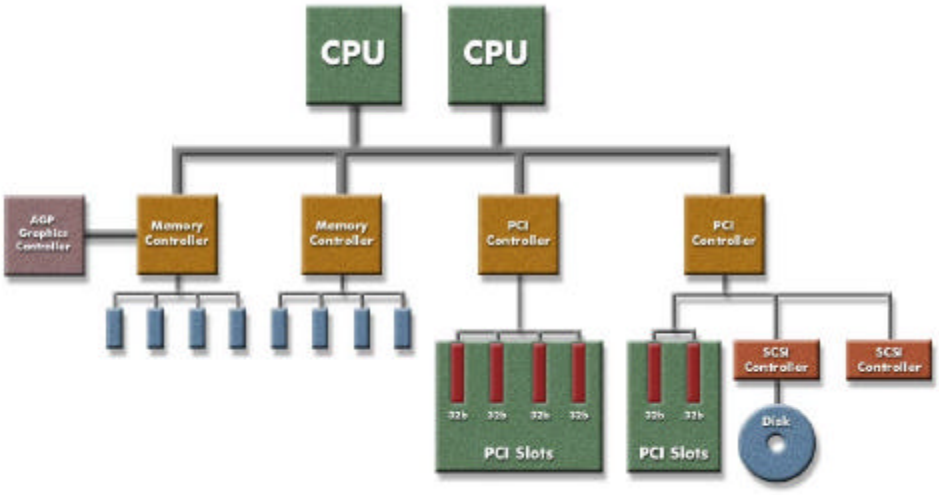

Figure 1. SP700 Highly Parallel System Architecture Implementation

DUAL MEMORY CONTROLLERS

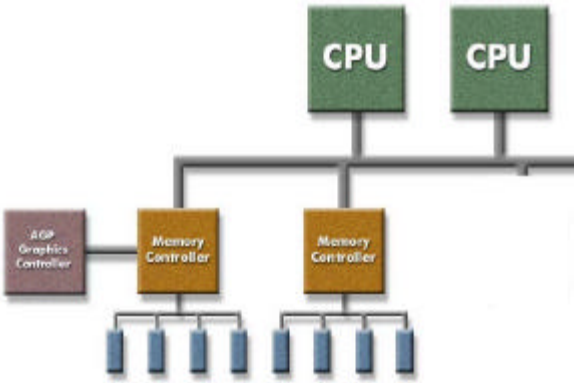

Figure 2. Dual Memory Controllers

The Compaq Professional Workstation SP700 uses dual memory controllers that can process memory requests in parallel, significantly increasing overall memory bandwidth. Other workstations in the Windows NT/X86 market that use a single memory controller, such as the Intel® 440BX/GX AGPset, offer memory bandwidth of up to 800 MB/s. The Compaq Professional Workstation SP700 uses two memory controllers, each with a bandwidth of 800 MB/s. Therefore, total memory bandwidth increases to 1.6 GB/s, up to twice that of other systems. The Compaq Professional Workstation SP700 uses industry-standard, 100-MHz Registered ECC Synchronous DRAM (SDRAM) that can be added in single DIMM increments. To ensure that both memory controllers in the Highly Parallel System Architecture are being used effectively and processing memory requests concurrently, memory should be balanced between the memory controllers as outlined below.

The Compaq Professional Workstation SP700 includes eight DIMM slots on the system board. DIMM slots one through four are associated with one memory controller and DIMM slots five through eight are associated with the other memory controller. To ensure optimum performance, the following table outlines the suggested memory configurations to use based on the amount of total memory desired.

Table 1: Guide for Configuring Dual Memory Buses to Optimize Performance in the Compaq Professional Workstation SP700

	Memory Bus 1				Memory Bus 2				
Memory Size	**DIMM Slot 1**	**DIMM Slot 2**	**DIMM Slot 3**	**DIMM Slot 4**	**DIMM Slot 5**	**DIMM Slot 6**	**DIMM Slot 7**	**DIMM Slot 8**	**Optimization Level****
64MB	1 x 32MB				1 x 32MB				1
64MB	1 x 64MB								2
128MB	1 x 32MB	1 x 32MB			1 x 32MB	1 x 32MB			1
128MB*	1 x 64MB				1 x 64MB				2
128MB	1 x 128MB								3
256MB	1 x 32MB	1 x 32MB	1 x 32MB	1 x 32MB	1 x 32MB	1 x 32MB	1 x 32MB	1 x 32MB	1
256MB	1 x 64MB	1 x 64MB			1 x 64MB	1 x 64MB			1
256MB*	1 x 128MB				1 x 128MB				2
256MB	1 x 256MB								3
512MB	1 x 64MB	1 x 64MB	1 x 64MB	1 x 64MB	1 x 64MB	1 x 64MB	1 x 64MB	1 x 64MB	1
512MB	1 x 128MB	1 x 128MB			1 x 128MB	1 x 128MB			1
512MB	1 x 256MB				1 x 256MB				2
512MB	1 x 512MB								3
1GB	1 x 128MB	1 x 128MB	1 x 128MB	1 x 128MB	1 x 128MB	1 x 128MB	1 x 128MB	1 x 128MB	1
1GB	1 x 256MB	1 x 256MB			1 x 256MB	1 x 256MB			1
1GB	1 x 512MB				1 x 512MB				2
2GB	1 x 256MB	1 x 256MB	1 x 256MB	1 x 256MB	1 x 256MB	1 x 256MB	1 x 256MB	1 x 256MB	1
2GB	1 x 512MB	1 x 512MB			1 x 512MB	1 x 512MB			2
4GB	1 x 512MB	1 x 512MB	1 x 512MB	1 x 512MB	1 x 512MB	1 x 512MB	1 x 512MB	1 x 512MB	1

* Indicates memory configuration of standard models

** The degree of performance optimization is indicated by a numerical range. Level 1 represents the best performance. Levels 2, 3, and 4 indicate progressively lower performance.

The memory architecture used on the Compaq Professional Workstation SP700 also allows for added flexibility when configuring memory by providing eight DIMMs. Users can expand to larger memory capacities without having to use newer, more expensive memory technologies. For example, the Compaq Professional Workstation SP700 can be configured with 1 GB of RAM by using eight 128-MB DIMMs instead of four 256-MB DIMMs. Currently, one 256-MB DIMM costs 50 percent more than two 128-MB DIMMs. So, using smaller capacity DIMMs is cost effective and delivers the best performance when the DIMMs are split between the two memory controllers.

The Compaq Professional Workstation SP700 can support up to 4 GB of system memory (using eight 512-MB DIMMs), up to twice the memory expandability of competitive Intel-based Windows NT systems. Larger memory expandability gives the Compaq Professional Workstation SP700 greater ability to run memory-intensive applications with large data sets, such as NASTRAN and VCS.

DUAL-PEER PCI BUSES

The Compaq Professional Workstation SP700 also uses dual-peer PCI buses to increase system I/O bandwidth. A single PCI bus provides I/O bandwidth of 133 MB/s, which must be shared by many key peripherals, such as the SCSI controllers, array controllers, and network interface controller (NIC). With dual-peer PCI buses, each bus can provide peak bandwidth in parallel with the other controller, allowing an aggregate I/O bandwidth of 267 MB/s. This implementation provides twice the bandwidth of single bus architectures.

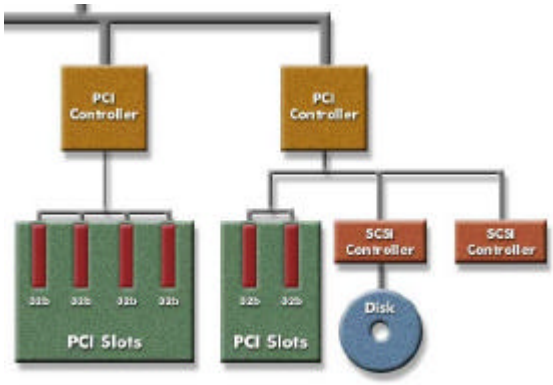

Figure 3. Dual-Peer PCI Buses

Another benefit of dual-peer PCI buses is the ability to balance system resources across the two buses to gain improved performance. By adding peripherals on separate PCI buses, devices do not have to compete for access on the same PCI bus, resulting in better performance and increased system throughput.

Finally, the dual PCI buses also allow for greater system I/O integration and expandability by supporting up to 12 PCI devices, which is twice the number supported on single bus implementations. This allows the Compaq Professional Workstation SP700 to deliver six available PCI-based I/O expansion slots while also integrating other PCI components, such as the SCSI and network controllers on the system board. Though other workstations may offer the ability to support more than six PCI devices, they achieve this support through the use of a PCI bridge. Although the bridge does extend the PCI bus and allows more devices to be connected, it still uses a single bus implementation with a maximum bandwidth of 133 MB/s. By extending the bus to accept more devices, this design can actually cause greater traffic on the PCI bus and may lower performance.

DUAL CHANNEL SCSI BUSES

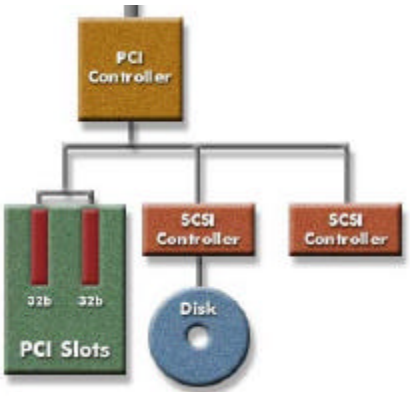

Figure 4. Dual Channel SCSI Buses

The Compaq Professional Workstation SP700 uses dual, independent channel Wide-Ultra SCSI controllers, which balance the disk subsystem work load and performance by placing high-performance peripherals on separate buses.

Dual SCSI buses provide the capability of separating lower performance SCSI devices, such as tape backup devices, from high performance devices, such as 10,000-rpm hard drives and RAID arrays. To achieve optimal performance, it is recommended that slower, non Wide-Ultra devices be separated on their own SCSI controller.

The dual Wide-Ultra SCSI implementation also doubles the bandwidth to the disk subsystem, providing an aggregate bandwidth of 80 MB/s (40 MB/s per controller) when compared to single SCSI bus systems.

AGP 2X SUPPORT

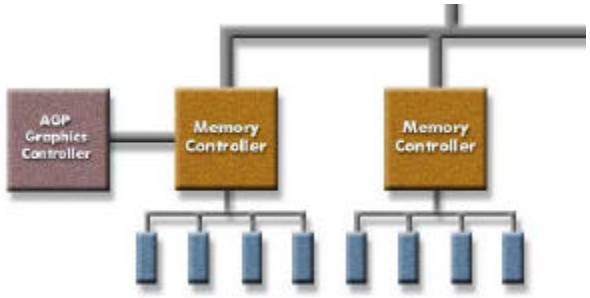

Figure 5. 2X AGP Support

The AGP bus is an I/O port that directly links the graphics controller to system memory. By providing a dedicated path to system memory, AGP provides faster graphics performance when 3D applications use texture mapping or extensive command lists that require more data support than is available in local memory on the graphics subsystem. The Compaq Professional Workstation SP700 fully supports the AGP 2X specification. AGP 2X runs at 66 MHz with an effective data transfer rate of 533 MB/s. On the Compaq Professional Workstation SP700, the AGP port is directly connected to one of the memory controllers. If the graphics controller requires more memory to store textures than is available on the primary controller, the AGP bus will also use memory from the secondary controller. Although AGP devices can access memory on either memory controller, the fastest performance is achieved when memory is accessed from the primary controller.

OPTIMIZED MULTIPROCESSING SUPPORT

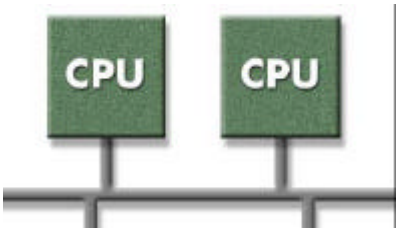

Figure 6. Optimized Multiprocessing Support

The Compaq Professional Workstation SP700 delivers optimized multiprocessing support by combining the Intel Pentium® II Xeon™ with the Compaq Highly Parallel System Architecture. Both the Intel Pentium II and Pentium II Xeon processors enable multiprocessor support by including circuitry in the processor that determines how multiple processors can share the CPU bus. Some manufacturers have added multiple processors to a typical desktop system design and called the end result a "workstation." Compaq takes multiprocessing to the next step with the Highly Parallel System Architecture by enhancing memory and I/O bandwidth as well. Multiprocessor systems designed without the Highly Parallel System Architecture will quickly encounter a bottleneck as the multiple processors try to access the other system resources, such as memory and I/O subsystems, that have not been enhanced to accommodate the additional data traffic. The Highly Parallel System Architecture significantly reduces these bottlenecks by incorporating enhanced subsystem resources, such as dual memory controllers and dual-peer PCI buses, to accommodate the increased data traffic from the multiple processors. The Compaq Professional Workstation SP700 also has the capability of handling eight simultaneous transactions, twice the capability of systems based on the 440BX/GX AGPset. By handling more simultaneous transactions, the Compaq Professional Workstation SP700 provides higher utilization and scalability than competing workstations

DUAL INDEPENDENT BUS ARCHITECTURE

Complimenting the Highly Parallel System Architecture, both the Pentium II and Pentium II Xeon use Intel's Dual Independent Bus architecture providing two (dual) independent buses: a processor-to-cache bus and a processor-to-memory bus. The processor-to-memory bus runs at the core system speed of 100 MHz. The processor-to-cache bus speed depends on which processor is being used. With the Pentium II Xeon used on the Compaq Professional Workstation SP700, this bus runs at the processor speed (that is, 400 MHz in a 400-MHz processor).

This design delivers significantly more bandwidth than a single bus architecture processor because the buses can work independently, which essentially doubles the throughput. As processor speeds increase, so will the speed of the processor-to-cache bus, which will allow performance to scale with the MHz.

CONCLUSION

The second generation of the Highly Parallel System Architecture implemented in the Compaq Professional Workstation SP700 further improves overall system performance by delivering increased bandwidth to critical subsystems including memory and I/O. Multiple data paths, large high-speed data buses, and balanced system resources make the Highly Parallel System Architecture the best choice for delivering uncompromising performance in today's demanding applications.