The Use of Dual Graphics Devices on the High-End HP xw9300 Workstation

The high-end of HP’s personal workstation product line—the HP xw9300 Workstation—is the first commercially available workstation to support two full-speed PCI Express graphics devices simultaneously. This capability provides unprecedented power to customers with graphics-intensive applications.
Introduction

The use of multiple displays on personal workstations is today a common enhancement to computer users’ productivity. Users benefit from the additional workspace—avoiding stacking window upon window on a single display. Further, because the cost of displays goes up exponentially with the size of the monitor, using multiple displays is an economical way of increasing screen real estate.

Until recently, however, personal workstation users that push the performance envelope of their graphics cards were not able to support multiple displays—at least at the high levels of performance demanded by 3D applications. In the past, users in the Oil and Gas, CAD, CAM, and DCC industries might have one high-performance 3D graphics card and another lower-performing card, but no workstation was able to support two high-end 3D cards simultaneously.

The situation has changed with the introduction of a new high-end workstation that employs multiple new technologies to achieve peak graphics performance on two 3D graphics cards simultaneously (or with one display—see SLI section, below). The HP xw9300 Workstation combines proven HP Workstation engineering with AMD Opteron™ processors and NVIDIA nForce Professional chipset technologies (see Figure 1). This pedigree gives the HP xw9300 the capability of supporting dual PCI Express x16 (“by sixteen”) channels—something no other workstation is currently able to provide.

Figure 1. The pedigree of the new HP Workstation xw9300.
The HP xw9300 Workstation architecture

Introduction

The architecture of the HP xw9300 Workstation leverages multiple new technologies, including:

- The use of PCI Express x16 for each of two separate graphics channels. Each x16 channel employs sixteen PCI Express lanes to provide 8 GB/second peak (4 GB/second in each direction) of bandwidth to the connected device.
- Dual AMD Opteron series 200 processors, featuring 32- and 64-bit addressing, AMD’s Direct Connect Architecture, an integrated memory controller, and the AMD HyperTransport™ processor interconnect technology.
- HP’s renowned workstation engineering capabilities, including a personal workstation package that provides up to 700 watts of power (specifically for high-end graphics cards that require large amounts of power), quiet cooling, completely tool-less chassis, and extensive connectivity options.
- NVIDIA nForce Professional and AMD 8131 chipsets for high performance I/O and extensive connectivity.
- The NVIDIA Quadro FX family of graphics solutions for PCI Express I/O interface. The NVIDIA Quadro FX family is specifically designed for high performance and high resolution needs of high-end 3D graphics applications. The product family also supports NVIDIA’s Scalable Link Interface (SLI). SLI allows custom high-performance graphics solutions, such as parallel rendering and compositing, even if a single display is used (see “SLI,” below).

These technologies are described in additional detail below.

Architecture

As shown in Figure 2, the HP xw9300 Workstation employs one or two AMD Opteron processors, each with multiple ports for memory, I/O, and processor-to-processor communication. In addition, the AMD Opteron processor enables simultaneous 32- and 64-bit computing.

The AMD Opteron processors feature an integrated (on-chip) DDR Memory Controller, reducing memory latency. Reduced memory latency is important for the many workstation applications that exhibit a high miss-rate on processor cache(s). Another benefit of the integrated memory controller strategy is that memory bandwidth is distributed across the processors, allowing the aggregate system memory bandwidth to double when the second processor is added.

Each memory controller is capable of supporting up 8 GB of ECC-protected memory, resulting in a total capability of 16 GB with both processors installed.
The heart of the processor and I/O interconnect is based on AMD HyperTransport technology. HyperTransport is a low latency, point-to-point, cache coherent link that increases the number of different data paths in the system, reducing bottlenecks and increasing performance.

HP’s experience of over twenty years of designing high performance graphics workstations results in the artful use of AMD and NVIDIA chipsets to provide a host of connectivity solutions, including:

- Two x16 PCI Express graphics channels
- Four channels of Serial ATA II (SATA II) disk I/O\textsuperscript{1},
- Ultra SCSI disk I/O,
- A high-performance implementation of Gigabit Ethernet,
- Multiple legacy PCI and PCI-X I/O channels.

### Graphics Subsystem

The core of the HP xw9300 Workstation graphics subsystem is the two x16 PCI Express channels, supporting two high-end graphics cards. (Actually, the PCI Express channels may be used for any device that is able to take advantage of the performance of the PCI Express interface).

PCI Express is the latest generation of the venerable PCI architecture. PCI Express is a radically new implementation of the PCI computer bus that uses existing PCI programming concepts and communications standards, but is based on a much faster serial communications system.

At the hardware level (the “physical” layer in PCI Express architecture terms), PCI Express is based on multiple low-voltage point-to-point differential serial interconnects called “lanes.” Lanes are combined to scale bandwidth; the physical layer supports x1 (“by one”), x2, x4, x8, x12, x16, and x32 lane widths. In the xw9300 Workstation implementation, each lane is clocked at

\textsuperscript{1} SATA II enabled
2.5 GHz bi-directional, resulting in 4GB/second of bandwidth in each direction for a x16 channel.

The PCI Express x16 channels are supported by the NVIDIA nForce Professional chipsets (NVIDIA calls these MCPs—media and communications processors). The NVIDIA MCPs are specifically designed to interface to the AMD Opteron processors via the AMD HyperTransport interface. This point-to-point interface is clocked at up to 1 GHz, providing up to 8 GB/s of bandwidth from the MCP to the processor to which it is attached.

Each PCI Express graphics channel supports an NVIDIA graphics card as shown in the table below. The NVIDIA cards feature up to 256 MB frame buffer memory, up to 28.8 GB/s memory bandwidth, 256-bit memory interface, and support for ultra high-resolution panels up to 3840x2400.

**Figure 3. Table of supported graphics cards.**

<table>
<thead>
<tr>
<th>Graphics Card</th>
<th>Interface</th>
<th>Memory</th>
<th>Memory Interface</th>
<th>SLI Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>NVIDIA Quadro NVS 400</td>
<td>PCI</td>
<td>64 MB</td>
<td>64-bit</td>
<td>-</td>
</tr>
<tr>
<td>NVIDIA Quadro NVS 280</td>
<td>PCI Express x16</td>
<td>64 MB</td>
<td>64-bit</td>
<td>-</td>
</tr>
<tr>
<td>NVIDIA Quadro FX540</td>
<td>PCI Express x16</td>
<td>128 MB</td>
<td>128 bit</td>
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<tr>
<td>NVIDIA Quadro FX1400</td>
<td>PCI Express x16</td>
<td>128 MB</td>
<td>256 bit</td>
<td>Yes</td>
</tr>
<tr>
<td>NVIDIA Quadro FX3400</td>
<td>PCI Express x16</td>
<td>256 MB</td>
<td>256 bit</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**NVIDIA’s Scalable Link Interface (SLI)**

For extreme performance with a single display, NVIDIA provides a technology called SLI, or Scalable Link Interface. The SLI effectively bands two NVIDIA PCI Express graphics cards together and allows them to work in parallel to provide higher levels of graphics performance than is possible with a single card.

The extra performance is handled entirely by the dual graphics cards and the SLI logic; the fact that two cards are being used is transparent to applications. The logic on the graphics cards cuts a display roughly in half, with one card handling the top part of the screen and the other card the lower half of the screen. The screen split is adjusted as necessary to maximize performance by dividing the rendering load evenly between the two graphics cards.
Comparison with other solutions

Comparison with AGP solutions

PCI Express graphics cards are expected to completely replace AGP over the next few years. Because of the architecture of PCI Express, it consumes less board space on the main system board, and has less stringent timing tolerances. These advantages, combined with higher performance make it inevitable that AGP will be phased out quickly—some estimates say over 2004-2005—and completely replaced by x16 PCI Express. All of the major graphics card vendors are delivering PCI Express graphics cards, and it is highly unlikely that any more innovation will take place on the AGP-based products.

Another advantage is that the PCI Express x16 card socket supports a more robust card retainer and simpler connectors (providing higher reliability) than AGP. PCI Express power specifications also enable higher performance graphics cards, which have higher power requirements—up to 75 watts, with a provision for external power connectors to support a total of up to 150 watts.

Lastly, and arguably the most important advantage, PCI Express offers higher memory-to-graphics card bandwidth than AGP. Figure 4 illustrates peak bandwidth comparisons for AGP 4x, AGP 8x, and various implementations of PCI Express. As can be seen, the HP xw9300 Workstation is the only workstation capable of full bandwidth on two x16 channels.

Other PCI Express solutions

Several workstation vendors have announced (or are expected to announce later in 2004) the capability to support dual PCI Express graphics devices. However, these implementations are
generally based on the latest Intel chipset (the E7525 “Tumwater”), which supports a single x16 graphics port and an additional x8 PCI Express channel (see “2 PCI-E x8/x16” entry in Figure 4).

**Conclusions**

HP is long known for applying the latest technologies to give their customers the highest levels of performance in reliable and cost-effective workstations. HP brings over twenty years of experience in working directly with customers, ISVs, and applications to the design of a new workstation. In areas such as application performance, graphics capabilities and performance, and workstation chassis design, HP’s attention to exactly what kinds of problems customers are solving often provides a more robust solution with a lower cost of ownership.

The HP xw9300 Workstation is the latest example of this HP experience and innovation—the combination of leading-edge graphics, I/O, and processor technologies provides a platform for users that have the highest demands for 3D graphics and processor performance. The HP xw9300 Workstation complements the entire HP workstation line-up; users that require the highest levels of graphics performance, especially in dual display configurations, are encouraged to evaluate the xw9300 Workstation.
For more information

www.hp.com/go/workstations  
HP Workstation home pages.

http://www.hp.com/workstations/pws/xw9300/  
Information specific to the HP xw9300 Workstation.

http://nvidia.com/  
HP Partitioning Continuum, HP, 2002

http://www.amd.com  
AMD home pages.

http://nvidia.com/page/sli.html  
Information on NVIDIA’s SLI technology

Information on NVIDIA’s PCI Express implementation