WHITE PAPER

Compaq Wide-Ultra SCSI-3 Technology

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Compaq Computer Corporation

Enterprise Storage and Options Division

Client-server technology is increasingly called on to meet corporate information technology needs. In client-server environments, the storage solution is a key element in determining overall system performance. To increase the data bandwidth of the storage subsystem, Compaq has integrated Wide-Ultra SCSI-3 technology into its servers and storage options. This technology offers higher performance for the storage subsystem and still allows customers to use their existing storage devices. This provides legacy storage protection, while laying the foundation for maximum potential performance to accommodate the more intensive networking environments of the future.

CONTENTS

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INTRODUCTION

Small Computer Systems Interface (SCSI) is an input/output (I/O) bus widely used in the computer industry to attach peripheral devices such as hard disk drives and tape drives to network servers. Standardization work for SCSI began several years ago. In 1986, the American National Standards Institute (ANSI) officially approved the SCSI specification as a standard that defined the mechanical, electrical, and functional requirements for attachment of SCSI peripheral devices. However, performance improvements in processors and peripheral devices over the years pushed the original SCSI standard to its limit. Consequently, enhanced versions of the SCSI standard have been developed to incorporate several new features that improve SCSI's performance and functionality. At the same time, each version of SCSI has maintained backward compatibility with all SCSI devices.

As the SCSI standard has evolved, Compaq's testing and integration of SCSI technologies in server and storage options has played a major role in SCSI's wide adoption in enterprise computing environments. Compaq's strategy is to provide enterprise computing systems that give customers a variety of scalable, multivendor configurations to suit their needs. Compaq's stringent hard disk drive qualification process and multivendor strategy reduces the risk associated with single-vendor solutions.

SCSI EVOLUTION

SCSI is the second-most popular interface used in computers today; the first is Integrated Drive Electronics (IDE). SCSI has several advantages over IDE that make it the preferred interface for servers. There are many different SCSI protocols, but basically, the protocols refer to the bus speed in MB/s (Regular, Fast, and Ultra) and the bus width (Narrow and Wide). This section describes these protocols and their evolution in the performance and functionality of the three versions of the SCSI standard.

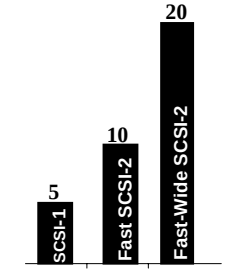
SCSI-1

The original SCSI standard, approved by ANSI in 1986, defined the first SCSI bus in terms of cabling length, signaling characteristics, commands, and transfer modes. The default (Regular) speed for SCSI was 5 MB/s. It had an 8-bit (Narrow) parallel bus that transferred a single byte of data with each bus cycle. "Regular" and "Narrow" conventions are no longer mentioned in the SCSI protocol names.

SCSI-2

The second version of the SCSI standard, SCSI-2, was approved in 1990. SCSI-2 was an extensive enhancement that defined support for many advanced features, including:

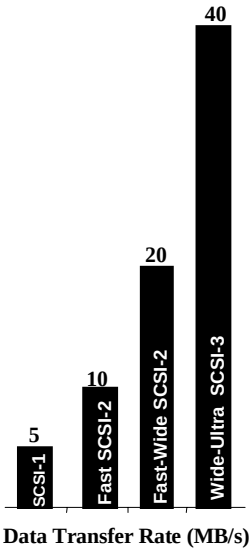
- *Fast SCSI*: A high-speed transfer protocol that doubles the speed of the bus to 10 MHz. With an 8-bit data pathway, the transfer rate is 10 MB/s.
- *Wide SCSI*: Widens the original 8-bit SCSI bus to 16 bits to permit more data throughput at a given signaling speed. The combination of Fast and Wide (*Fast-Wide SCSI-2*) offers data transfer rates up to 20 MB/s.
- *More Devices per Bus*: Wide SCSI buses support 16 devices as opposed to eight with regular (Narrow) SCSI.



- *Better Cables and Connectors*: SCSI-2 defined a new high-density 68-pin "B" cable and connectors.
- *Active Termination*: Provided more reliable termination of the bus.

In addition to these features, SCSI-2 maintained backward compatibility with all SCSI devices.

SCSI-3



SCSI-3 is a group of documents that define the implementation of SCSI protocols on different physical layers (SCSI-3 Parallel Interface, High Performance Serial Bus, Fibre Channel, and Serial Storage Architecture). Each physical layer has different performance characteristics and uses different hardware. Other documents in the SCSI-3 standard are still being developed. Currently, the SCSI-3 standard includes SCSI-2's performance and functionality enhancements plus:

- *Ultra SCSI*: Doubles the bus speed to 20 MHz and the transfer rate to 20 MB/s with an 8-bit data pathway.
- *Wide-Ultra SCSI-3*: Doubles the Ultra SCSI transfer rate to 40 MB/s using a 16-bit data pathway.
- *Improved Cabling*: A new 68-pin "P" cable replaces the "B" cable for use with Wide SCSI.

Compaq has extensively tested and integrated the Wide-Ultra SCSI-3 technology in Compaq servers and storage options because it allows the highest available performance in a SCSI host interface and because its backward compatibility provides investment protection for Compaq customers. Wide-Ultra SCSI-3's compatibility and performance benefits are described in the following sections.

WIDE-ULTRA SCSI-3 COMPATIBILITY

Wide-Ultra SCSI-3 is backward compatible with previous generations of SCSI, which means that Wide-Ultra SCSI-3 devices can use the same cables, connectors, and terminators as Fast-Wide SCSI-2 devices. Also, a mixture of Wide-Ultra, Fast-Wide, and Fast SCSI drives can coexist on the same SCSI bus. The decision to operate using a particular SCSI protocol is made on a drive-by-drive basis during the "negotiation phase" between each drive and the SCSI controller. This negotiation phase occurs as part of the boot-up process. A SCSI controller is a SCSI device that acts as the gateway between the SCSI bus and the server's internal I/O bus. The SCSI controller transfers commands and data between devices on the SCSI bus and the server.

The maximum transfer rate between the SCSI controller and each disk drive on the bus is determined by the native protocol of the slowest device. It is possible for a Fast-Wide SCSI-2 controller to communicate with both Fast-Wide SCSI-2 disk drives and Wide-Ultra SCSI-3 disk drives. If a Wide-Ultra SCSI-3 disk drive is attached to a Fast-Wide SCSI-2 controller, the maximum data transfer rate is that of the Fast-Wide SCSI-2 controller. The inverse is also true—a Wide-Ultra SCSI-3 controller can be used with Fast or Fast-Wide SCSI-2 drives. For the two devices to operate in Wide-Ultra SCSI-3 mode, both the SCSI controller and the disk drive must be Wide-Ultra SCSI-3 enabled.

Warning: Overriding the automatic sensing function by using third-party external storage products and implementing Wide-Ultra SCSI-3 in an external storage system may result in data corruption or data loss. This can best be avoided by using complete Compaq internal/external storage products.

When a Compaq two-channel Wide-Ultra SCSI-3 Controller or a Compaq SMART-2 Array Controller is connected to a Compaq ProLiant Storage System or ProLiant Storage System/F, the Compaq SCSI drivers automatically set the transfer rate externally to 20 MB/s (Fast-Wide SCSI-2). On the other hand, when a Compaq ProLiant Storage System/U is connected to the same controllers, the Compaq SCSI drivers will automatically set the transfer rate externally to 40 MB/s (Ultra-Wide SCSI-3). In most cases, this automatic sensing will not take place using non-Compaq SCSI products.

WIDE-ULTRA SCSI-3 PERFORMANCE BENEFIT

The performance benefit of Wide-Ultra SCSI-3 versus Fast-Wide SCSI-2 is *application and configuration specific*. In environments where servers randomly access small blocks of data from disk drives (file, print, and application servers), Wide-Ultra SCSI-3 offers no significant performance benefit over Fast-Wide SCSI-2. This is because the access time of disk drives, not the data transfer rate, is most important when dealing with small blocks of data. The graph in Figure 1 illustrates this point.

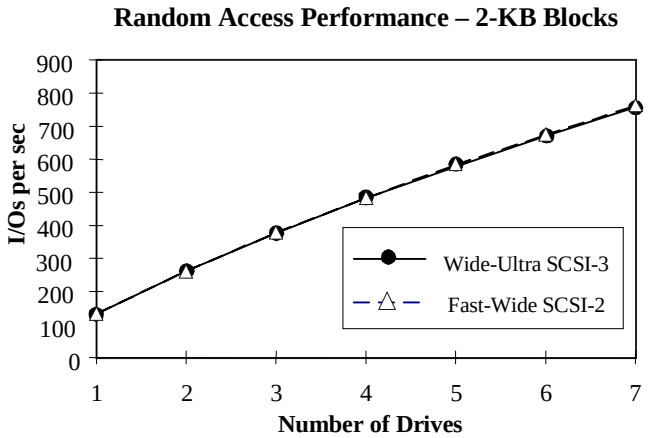


Figure 1: Wide-Ultra SCSI-3 shows no performance benefit over Fast-Wide SCSI-2 when accessing small (2-KB) data blocks in a random fashion.

However, in environments where large sequential transfers are the norm (such as storage systems and image processing), Wide-Ultra SCSI-3 offers a dramatic performance benefit over Fast-Wide SCSI-2 due to the faster transfer time of large blocks of data (Figure 2).

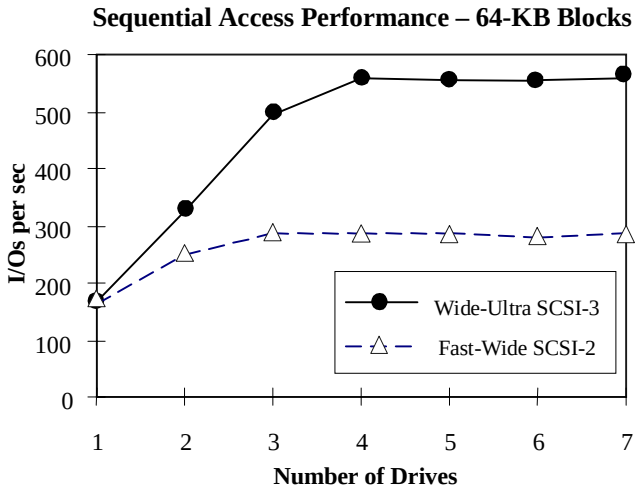


Figure 2: Wide-Ultra SCSI-3 shows significant performance benefit over Fast-Wide SCSI-2 when transferring large (64-KB) data blocks in a sequential fashion.

Wide-Ultra SCSI-3 increases the maximum possible data transfer bandwidth. However, if there is no bandwidth bottleneck using Fast-Wide SCSI-2, Wide-Ultra SCSI-3 may not improve the system performance.

COMPAQ'S IMPLEMENTATION OF WIDE-ULTRA SCSI-3 TECHNOLOGY

Compaq set the pace in the storage industry by implementing Wide-Ultra SCSI technology well before the SCSI-3 documentation was completed. As a result, Compaq customers did not have to wait to take advantage of 40 MB/s data transfers in Compaq SMART-2 Array Controllers and Wide-Ultra SCSI disk drives. When the Wide-Ultra SCSI-3 documentation was completed, these Compaq devices were already SCSI-3 compliant.

While the increase in bus speed from Fast SCSI to Ultra SCSI offers better performance, it also requires more stringent SCSI bus termination requirements. Proper termination ensures that voltages and signals are accurately propagated along the bus. Due to the data integrity issues surrounding the use of passive termination, Compaq chose to use active termination on all its SCSI technologies from the beginning. This additional step, while costing more to implement, added another layer to data protection and security, which are the hallmarks of Compaq storage innovations.

Faster SCSI bus speeds also increase the likelihood of signal corruption over longer distances, hence, faster buses are usually restricted to shorter cables. The maximum cable length for single-ended SCSI buses normally decreases by half each time the speed doubles. For example, the maximum cable length for Fast SCSI is normally 9 feet (3 meters) while the maximum Ultra SCSI cable length is 4.5 feet (1.5 meters).

Compaq has qualified 12-foot cables in Fast, Fast-Wide, and Wide-Ultra rack solutions, and qualified 6-foot cables for tower solutions. Compaq overcame the Fast SCSI and Ultra SCSI cable length restrictions by using specially designed expander chip technology. An expander chip is a device that joins independent SCSI bus cables, so the cables appear as a single SCSI bus to all attached devices. The expander chip technology allows the data signal to be "re-powered" at the same strength as the previous SCSI protocol but allows the data bandwidth to function at the faster protocol. The result is Compaq-qualified cables that support a combination of the longer cable length (6 feet and 12 feet) and the faster data protocol from Wide-Ultra SCSI-3. The only cable with the 4.5-foot restriction is the daisy chain cable for the Compaq SCSI Storage Expander.

COMPAQ WIDE-ULTRA SCSI-3 PRODUCTS

Compaq offers a full range of Wide-Ultra SCSI-3 compliant products including the ProLiant Storage System/U, disk drives (2.1, 4.3, 9.1, and 18.2 GB), SCSI controllers, and SMART-2 Array Controllers. Compaq extensively tests and optimizes all these Wide-Ultra SCSI-3 products for seamless integration with Compaq servers. For a list of Compaq ProLiant servers that support Wide-Ultra SCSI-3, see our website at http://www.compaq.com/smb/servers.html.

Compaq ProLiant Storage System/U

The ProLiant Storage System/U is the first Compaq drive expansion enclosure to offer 40 MB/s data transfer outside the server. In addition to offering the highest interface performance available, the ProLiant Storage System/U offers high storage density and high-availability features to reduce downtime (http://www.compaq.com/products/servers/storage/systemu-execov.html).

The ProLiant Storage System/U will replace the ProLiant Storage System/F, and is backward compatible with most Compaq legacy drive trays and controllers. Customers can upgrade the ProLiant Storage System/F to the ProLiant Storage System/U by using an upgrade kit, which is available for single-bus, dual-bus, and recovery server option models. The upgrade is as simple as replacing the I/O board in the ProLiant Storage System/F and updating the software.

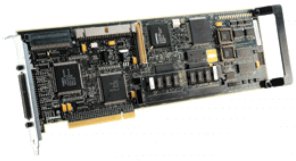
To operate at the 40 MB/s data transfer rate, all of the storage system's components must support Wide-Ultra SCSI-3 technology, including:

- Compaq Wide-Ultra SCSI-3 disk drives
- Compaq SMART-2 PCI Array Controller or Wide-Ultra SCSI-3 Controller
- Firmware Ver. 1.96 or higher [available in Options ROMPaq Ver. 2.4 (SoftPaq #SP3596) for SMART-2/P, SMART-2SL, and SMART-2DH Array Controllers] http://www.compaq.com/support/files/server/softpaqs/Rompaq/OPTROM.html
- ProLiant Storage System/U I/O board (included in upgrade kit)
- Wide-Ultra SCSI-3 software driver update using SmartStart Ver. 3.5 (included in upgrade kit)

Compaq SCSI Controllers

Compaq's Wide-Ultra SCSI-3 Controller began shipping with Wide-Ultra capable hardware in October of 1996. These controllers are available in single- and dual-channel configurations. They have been optimized for high performance and flawless operation with Compaq SCSI devices. Compaq controllers without Wide-Ultra SCSI-3 capable hardware cannot be upgraded to operate in Wide-Ultra SCSI-3 mode.

Compaq SMART Array and Non-Array Controllers



Compaq's SMART-2 Array Controller has been shipping with Wide-Ultra SCSI-3 capable hardware since June of 1996. By running the Compaq diagnostic utility "Inspect," customers can identify the revision level of the SMART-2 Array Controller in their system. Revision B of the controller incorporates Wide-Ultra SCSI-3 technology.

The Compaq SMART-2DH, SMART-2SL, and SMART-2/P* Array Controllers are Wide-Ultra SCSI-3 compatible; however, a firmware upgrade may be needed to allow the drives to operate at 40 MB/s in the ProLiant Storage System/U.

**Note: The SMART-2/P Array Controllers shipped from February to June 1996 do not support Wide-Ultra SCSI-3 data rates in the hardware. By running the Compaq diagnostic utility "Inspect," a customer can identify the revision level of their SMART-2/P Array Controller. Revision "B" of the controller incorporates Wide-Ultra SCSI-3 hardware support. The EISA version SMART-2E only supports Fast-Wide SCSI-2.*

Compaq Hard Disk Drives

Compaq Wide-Ultra SCSI-3 drives run on all existing Compaq SCSI-based server platforms. They contain a 16-bit interface that transfers data at rates up to 40 MB/s. Customers who upgrade to Compaq Wide-Ultra SCSI-3 Controllers and Compaq Wide-Ultra SMART Array Controllers in their servers will have the fastest SCSI drives and SCSI controllers available.

CONCLUSION

With Compaq quality testing and integration, customers can be confident that backward compatibility, flexibility, performance, and data integrity are the highest priorities. Furthermore, Compaq will continue to integrate the latest SCSI technologies into future servers and storage options to give customers the highest reliability and best performance available.