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Assessing and Comparing Serial Attached SCSI and Serial ATA Hard Disk Drives and SAS interface

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Scope of Paper

This paper provides guidance and recommendations for customers when deciding to implement HP serial ATA (SATA) or HP serial attached SCSI (SAS) technology in server environments. Comparisons on cost, performance, benefits, ideal audience, and architecture are included. This paper focuses only on the SATA and SAS HDDs and interfaces, and does not directly address parallel ATA, parallel SCSI, or Fibre Channel hard drive technology.

Introduction

In today's distributed enterprise with larger, more complex applications than ever before, an increase of mission-critical data moving to the server and continued server consolidation, storage has become more important than ever. At HP, we realize hard drives and interfaces are core components of customers' primary storage system, which contains everything from the most critical data to the operating system upon which equipment depends. HP is committed to delivering the highest quality products to ensure the integrity and availability of customers' data.

Serial Technology and HP

Today's HDD business is focusing on new serial technology that is emerging, including serial SATA and SAS interfaces. This technology allows customers unprecedented flexibility in choosing the right class of storage that meets their requirements.

In the near future, and with the advent of serialized architectures, key solution providers like HP will be able to provide one system or storage solution that will meet the requirements for a broad range of storage applications.

Overview of SATA Technology

SATA is a 1.5 Gb/s serial point-to-point architecture with a primary focus on low cost. The SATA desktop disk drives are available up to 250GB, 7.2K rpm.

SATA interface



SATA technology was developed directly to replace the legacy desktop parallel ATA (PATA) interface. The SATA interface is designed to meet the requirements of desktop devices and entry-level server deployments and is tied to the desktop devices discussed later in this paper.

SATA technology offers customers and system builders the lowest acquisition cost by leveraging the volume of the desktop market with the opportunity to add entry level functionality such as hot-plug and command queuing in the future. SATA also brings a smaller pin-count on the cable connectors, and a transfer rate starting at 150MB/s.

SATA's ideal audience includes customers who have desktop and entry-level servers that provide a low cost per gigabyte.

Serial ATA

The discount shop

- **Production:** 2003 (second half)
- **Minimum feature set**
- **Evolution of Parallel ATA**
- **Extremely cost sensitive**
- **Positioning:** non-mission critical
- **Target:** reference
- **Applications:** internal boot devices, low cost nearline tape staging
- **Strategic business linkage to SAS**



Why SATA?

The advantages of SATA technology include:

- Parallel ATA technology is approaching its physical transfer rate limit.
- SATA has smaller cables and a smaller pin count.
- SATA offers a growth path to keep up with disk drive data rate increases.
- Point-to-point data transfer starts at 1.5Gb/s.

Overview of SAS Technology



SAS is the logical evolution of SCSI, including its long-established software advantage and its multi-channel, dual-port connection interface for enterprise servers.¹

Leading vendors and suppliers in the enterprise computing and storage technology industries – HP, IBM, LSI Logic, Maxtor, and Seagate – were the original advocates of the SAS interface. Recently, the STA T10 board of directors voted to define SAS as the next generation of SCSI after the Ultra 310.

High performance, high reliability SAS enterprise disk drives will initially be available in a 3.5" form factor at 10K up to 72GB and 15K rpm up to 146GB and a new small 2 1/2" form factor at 10K rpm up to 36GB. Future releases will include 15K rpm as well as the 3 1/2" form factor at 10K.

SAS technology was designed to address the storage interconnect requirements of enterprise computing environments. SAS technology pulled from and combined with several great aspects of Fibre Channel, SCSI, and SATA to create an enterprise class interface that replaces parallel SCSI. This technology provides customers with the same high performance and high reliability they knew before, while adding the unprecedented feature of a solution that accommodates both SAS and SATA devices.

SAS

The mainstream retailer production: 2004



- Feature-rich SCSI base command set
- Evolution of SCSI pre-empt and bypasses U640
- Opportunity for cost-sensitive or high reliability choice
- Positioning: 24 x7 operations
- Target: mid-range to high-end servers
- Applications: I/O intensive database
- Multi-lane for tiering
- Universally supports SATA devices

¹ Susan Bobholz. "Serial Attached SCSI & Serial Compatibility". Authored by Intel on behalf of SPA. 2000.

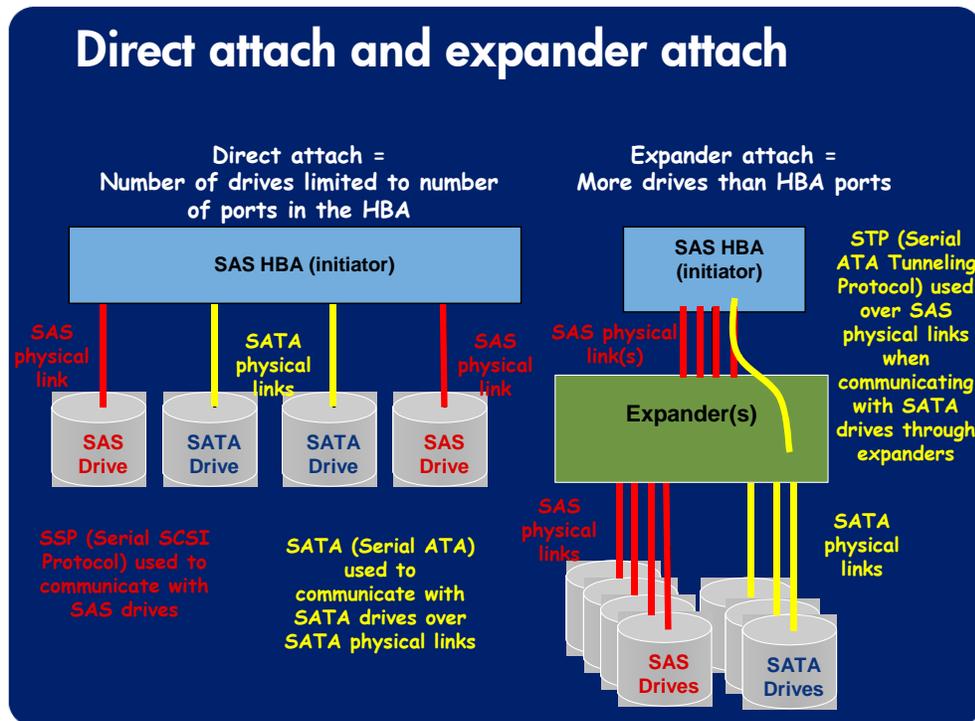
SAS interface

The SAS interface is planned to provide customers with the flexibility, reliability, and performance for enterprise devices. SAS interconnect gives customers the choice of SATA or SAS interfaces. Customers who have midrange to high-end enterprise servers and workstations, who have mission-critical data, and who need scalability and performance are the ideal audience for the SAS interface.

SAS controllers communicate with SATA devices by using a SATA tunneling protocol (STP). SATA devices recognize only SATA communications.

SAS enables one system design to deploy either SAS or SATA devices. This enables a flexible solution in offering a choice in storage devices based on what attributes are required. (Reliability, Performance, Cost).

Figure 1. •SAS interface allows for communication in both directions on a link simultaneously



Why SAS?

SCSI disks are designed and manufactured to meet the enterprise requirements of high reliability and high mean-time-between failure (MTBF). HP does not actually speak in terms of MTBF as we measure in terms of Annual Failure Rate (AFR). HP believes that it makes more sense to the customer to give a percentage chance of failure over the given year rather than to suggest that the duty cycle is going to be over a million hours for a given drive.

The formula for converting MTBF to AFR is as follows: $1/MTBF = AFR/8760$ hrs per year. So then, for example, 1.5 million hours MTBF will equal .58% AFR.

The high rotational speeds of SCSI drives (10K and 15K rpm), combined with low seek times and higher onboard processing power, result in the highest performing drives available. SAS meets these performance demands while providing a highly scalable, high performance storage interconnect.

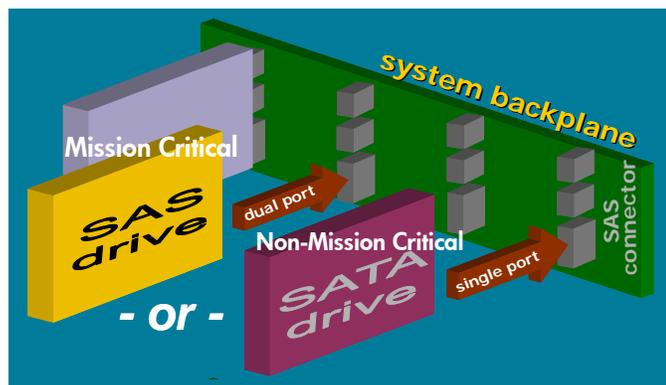
The following are other advantages of choosing SAS technology:

- Higher bandwidth 300MB/s point-to-point links.
- Allows the grouping of multiple links for wide links in multiples of 300MB/s.
- Allows the choice of SAS and/or SATA drives in the same infrastructure.
- Traditional SCSI software and middleware.
- Smaller connectors allow for small form factor hard disk drives.
- Simplified signal routing and thinner cabling.

**SATA and SAS
Hard Disk Drives
Differentiators**

A natural question arises from SAS/SATA compatibility: When should customers specify SATA disks, and when should they use SAS disks? The answer is based on the inherent differences between SCSI disk drives and ATA disk drives today. Again, SATA hard disk drives are designed for low cost environments, while SAS hard disk drives are used for supporting many users simultaneously. These drives also contain devices and components which are crucial in determining the type of drive customers should choose. SAS drives are tailored to support mission-critical data in applications where performance, reliability and availability are key requirements. SAS disks will continue this trend and also move towards smaller form factor drives as enterprise requirements change. In addition, SCSI's 20-year history of software and middleware are preserved in SAS drives.

Figure 2. SAS architecture can accommodate either SAS or SATA disk drives.



In order to choose either a SATA or SAS solution depends on the customers' requirements. For instance, if you're in the transport business and you're buying a motor vehicle, you need a truck rather than a roadster. But if you're transporting people, you need a bus rather than a truck and the comfort level and size of the bus depends on the number of passengers and the distance you need to travel, not to mention the price of the fare. In other words, every application has its own characteristics and idiosyncrasies.

Continuing with the highway analogy, SATA is a 1-lane farm to market road, but SAS is a multi-lane interstate. The SATA devices are the trucks; the SAS devices are the sports cars. Multiple lanes allow for the sport cars not to be slowed down by the trucks when they are on the same highway. The customers get to choose how many truck and cars have to share the roadway.

In another example, at one end of the storage market there's a single user who needs to surf the net, balance the checkbook, and e-mail pictures of the kids to relatives in Australia—a basic need requiring basic equipment at the lowest cost (SATA). At the other end of the market, there's a city bank running corporate payrolls and real-time market analysis for its international subsidiaries at the other end of its intranet—a sophisticated need requiring state-of-the-art equipment, high availability, and guaranteed mission-critical data security (SAS). Table 1 on the following page gives customers an at-a-glance feature comparison of SATA and SAS technology.

Table 1. SATA and SAS Drive Technology Comparison Table

	SATA desktop	Enterprise SAS
Evolution from	Parallel ATA	Parallel SCSI
Driver Model	Software transparent from Parallel ATA	Software transparent from legacy SCSI
Performance (Access to Data)		
Latency + Seek Time	13m/sec @7200 RPM	5.7m/sec @15K RPM
Rotational Vibration	5 to 12 rad/sec/sec	21 rad/sec/sec
Typical I/Os per sec/drive (no RV)	77	319 ²
Typical I/Os per sec/drive (10 rad/sec)	35	319
Typical I/Os per sec/drive (20 rad/sec)	<7	310
Duplex Operation	Half	Full
Connectivity/topology	4 devices (no peer-to-peer)	>16K devices, peer-to-peer
Customization		
Unique Code and Hardware	Limited	Extensive
Variable Sector Sizes	No	Yes
Mode Page Parameter Control	No	Yes
Inquiry Data	No	Yes
Diagnostic Pages	No	Yes
Capacity Controls	No	Yes
Indicators		
Activity LED	No	Yes
Reliability		
MTBF	600K/hrs	1.2M/hrs
Duty Cycle	8 x 5	24 x 7
Interactive Error Management	No	Yes
Internal Data Integrity Checks	No	IOEDC ³
Dual Port	No	Yes
Signal rate	1.5Gb/s	1.5Gb/s and 3.0Gb/s

² Queue = 16³ Input/Output Error Detection Code

SAS Interface Benefits

The collaboration of the SATA and SAS features will result in unprecedented system configuration capabilities with multiple benefits to system builders and IT professionals. System builders will be able to utilize a common infrastructure and choose from a wider range of product options, meeting basic to highly complex storage requirements.

For the first time, storage systems will be readily customizable to meet specific application workloads and price points. IT professionals and users will be able to configure simplified and flexible systems.

Ultimately, customers will have choices that allow them to optimize their applications to achieve a balance of performance, reliability, and total cost of ownership.

Other advantages of SAS leveraging SATA interconnect technology include:

- **SAS/Serial ATA compatibility**
- **Universal Interconnect**
- **Simplified Cabling – thinner cables improve chassis airflow**
- **Flexibility – Disk/backplane interoperability for flexible SAS and SATA deployment options**
- **Point-to-point topology – dedicated disk connections with scalable throughput**
- **Common infrastructure: cables, connectors, backplanes, cabinets, etc.**
- **Efficiencies in provisioning the market**
- **Support for a broad range of market application segments based on performance, reliability, and TCO**
- **Simpler integration experience**

SATA and SAS Interface Differentiators

During initialization, a SAS system that implements all three SAS protocols recognizes the type of drive connected to each port and adjusts the differential voltage levels to match the drive.

Table 2. SATA and SAS Interface Comparison

	SATA	SAS
Topology	Point to Point	Point to Point with expanders
Addressing	1	128
Distance (m)	1	10
Dual Port	No	Yes
Connection	P to P**	P to P*
Performance		
Speed MB/s	150, 300, 600	150, 300, 600
Duplex	Half	Full
A full duplex allows for communication in both directions on a link simultaneously. SAS will ship full duplex first generation.		
Protocol	ATA	SCSI
Note: * Point to Point with Expanders providing Addressability **Point-to-Point with Port Multiplier providing Addressability ***External cable. Transmission levels are higher than SATA to support backplane use.		

SATA Desktop Devices and SAS Enterprise Devices

However, customers must consider more than interfaces when choosing drives and interfaces. Serial devices also play a part in these solutions as described below.

Cost. Each component of a drive must become more complex in order to deliver state-of-the-art performance, capacity, and reliability, while at the same time being pushed to become less costly to build.

Seek Times. Fast seeks cost more and target the enterprise market. This includes larger magnets, better bearings, and advanced design actuators. Also enterprise drives have greater on board processing power to accommodate faster seeking and lower response times.

Rotation. Latency is improved by spinning the media faster. SATA drives are much slower to adopt the performance improvements first introduced in enterprise drives.

Who are SATA customers?

With the various choices, customers should look at each serial technology to determine what attributes are most important to the customers' application requirements.

SATA customers look for:

- Lowest acquisition cost available.
- Simplified connector, back-plane design, and thinner cables.
- Ease of serviceability – hot-plug.
- Storage that can be used in new ways, including bulk storage.
- Fewer signals to route compared to PATA.
- Dedicated connection per HDD.

Who are SAS customers?

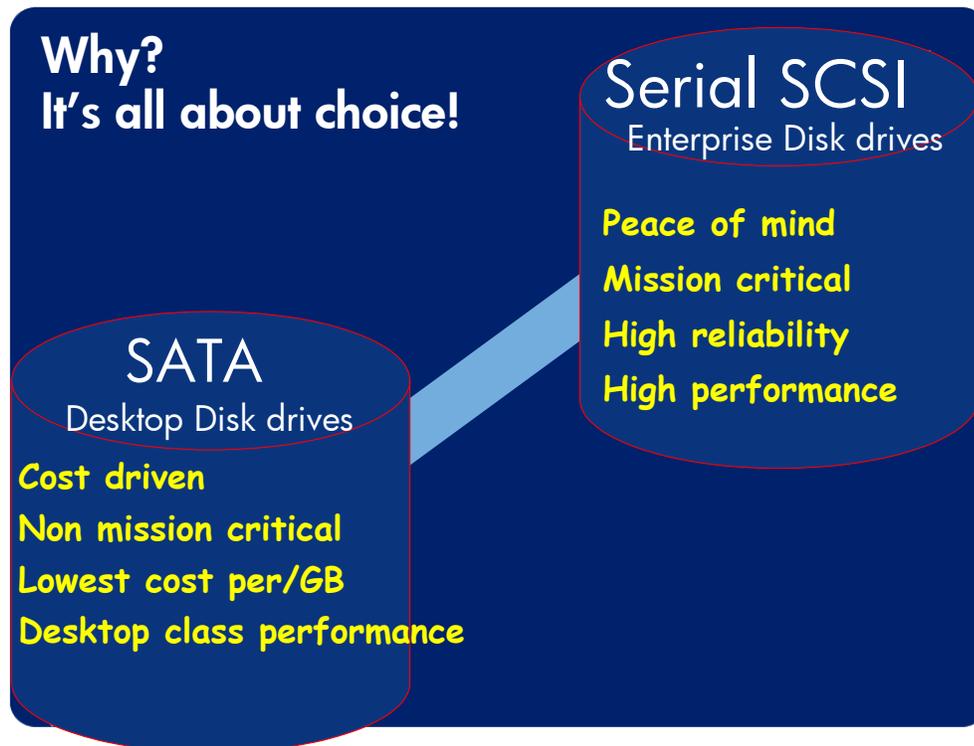
SAS customers look for:

- Logical extension to the parallel SCSI interface.
- Topology with an increased device count, and point-to-point architecture that provides significant increase in bandwidth per device.
- Improved connectors and simplified, thinner cabling.
- Very high scalability.
- The highest IOPS.
- Bypassing the technical hurdles of Ultra640 SCSI.
- Configuration flexibility and simplicity.
- Improved performance and reliability features.
- Scalable I/O with future growth roadmap.
- Traditional SCSI software and middleware.

Summary: HP Customers Have a Choice

It is critical for customers to be aware how to choose the right serial solution for their requirements. HP believes customers should study the characteristics of both SATA and SAS technologies in order to comprehend the benefits and tradeoffs for each hard drive and interface feature. In a nutshell, Figure 2 below is a guideline to direct customers to the top serial technology.

Figure 2.
Choosing
Between SATA
and SAS



HP recommendations

HP advises that customers who require an inexpensive price for server and storage deployments should choose serial ATA.

- Serial ATA is the best choice for desktop, servers, and networked storage where price is the only primary selection factor.
- Serial ATA enables a low-cost alternative for storage feature and performance enhancements built on the current trend of servers and networked storage.
- Serial ATA is rapidly evolving to be the industry standard disk interface for the desktop and cost-sensitive server market segments.

SATA = Desktop class disk drives

- **Lowest cost per GB (leverages desktop volumes)**
- **Lower performance (tuned for a single user)**
- **Lower reliability (designed for home PC use)**

HP recommends customers who require performance, reliability, and software consistency should choose SAS.

- SAS is the best choice for mainstream and mission critical enterprise server and storage market segments.
- SAS meets the requirements for enterprise storage by providing strict quality, reliability standards and universal compatibility.
- SAS is evolving from 20 years of SCSI infrastructure; enabling better performance, scalability, and flexibility.

SAS = Enterprise class disk drives

- Best cost per I/O (highest rpm's and seek times)
- Highest performance (tuned for multi user)
- Most reliable (designed for 24x7 server use)

The need for SAS. Serial technology allows companies like HP to help customers deploy a standardized server product while providing the ability to “customize” storage. While low-cost serial ATA disks will be ideal for near-line applications, SAS disk performance and uptime requirements will meet the needs of mainstream server and storage applications. Users may decide to deploy a single server model or storage enclosure across the enterprise, but then customize the hard drives based on the individual requirements—one of the key benefits of this serialized architecture.

BOTTOM LINE. HP is committed to delivering the highest quality products to ensure the integrity and availability of customers’ data. When customers buy an HP storage solution, they are reassured that one of the latest serial technologies will fit their unique needs.

For More Information

More information on SATA vs. SAS technology can be located at:

www.t13.org –SATA spec development, meeting notes, presentations, proposals

www.serialata.org –SATA working group website

www.t10.org –Serial attached SCSI spec development, meeting notes, presentations, proposals

www.scsita.org –Serial attached SCSI marketing and business information

Contacts: If you would like to provide feedback, please mail to: Levi.Norman@hp.com

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Capacity and small form factor enterprise hard drive information is located at:

<http://www.hp.com/products/harddiskdrives> and <http://www.hp.com/go/serialT>

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