

SAS and SATA: Unparalleled serial interface compatibility

For over 20 years, the parallel bus interface has been the mainstream storage interconnect for most storage systems. But increasing bandwidth and flexibility demands have exposed inefficiencies in the two main parallel interface technologies: SCSI and ATA. The lack of compatibility between parallel ATA and SCSI - including different connectors, cables and software - increases costs for inventory management, R&D, training and product qualification.

While parallel technologies meet most performance requirements of today's enterprise solutions, continued demands for higher speeds, more robust data integrity, smaller designs and wider standardization cast doubt on the ability of parallel technology to economically keep pace with increasing CPU processing power and disk drive speeds. In addition, shrinking budgets are making it increasingly difficult to sustain the costs of developing and managing multiple backplane types, validating multiple interfaces and stocking multiple I/O connections.

Parallel technology poses still other challenges. Parallel transmissions are susceptible to crosstalk across wide ribbon cable paths. This crosstalk adds line noise and can cause signal errors, a pitfall that has been remedied by slowing the signal, limiting cable length or both. Terminating parallel signals is also difficult, requiring individual lines to be terminated, usually by the last drive, to avoid signal reflection at the end of a cable. Finally, parallel's large cable and connector size make it unsuitable for increasingly dense computing environments.

Introducing SAS and SATA

Serial technology, specifically Serial ATA (SATA) and Serial Attached SCSI (SAS), addresses the architectural limitations of its parallel counterparts. The technology draws its name from the way it transmits signals, that is, in a single stream (serially) compared with the multiple streams found in parallel technology. The main advantage of serial technology is that while it moves data in a single stream, it does so much faster than parallel technology because it is not tied to a particular clock speed. Serial technology wraps many bits of data into packets and then transfers the packets up to 30 times faster than parallel down the wire to or from the host.

SATA extends the ATA technology roadmap by delivering disk interconnect speeds starting at **1.5G bps(187 MB/s)**. Due to its lower cost per gigabyte, SATA will continue as the prevalent disk interface technology in desktop PCs, sub-entry servers and networked storage systems where cost is a primary concern.

SAS, the successor technology to the parallel SCSI interface, leverages proven SCSI functionality and promises to greatly build on the existing capabilities of the enterprise storage connection. SAS offers many features not found in today's mainstream storage solutions. These include drive **addressability of up to 16,256 devices per port** and reliable point-to-point serial connections at speeds of up to **3G bps (375 MB/s)**.

In addition, due to its small connector, SAS offers full dual-ported connections on 3.5-in. and smaller 2.5-in. hard disk drives, a feature previously found only on larger 3.5-in. Fibre Channel disk drives. This is an essential feature in applications requiring redundant drive spindles in a dense server form factor such as blade servers.

SAS improves drive addressability and connectivity using an expander that enables one or more SAS host controllers to connect to a large number of drives. Each expander allows connectivity to 128 physical links, which may include other host

connections, other SAS expanders or hard disks. This highly scalable connection scheme enables enterprise-level topologies that easily support multi-node clustering for automatic failover availability or load balancing.

In one of its most significant advances, the SAS interface will also be compatible with lower-cost-per-gigabyte SATA drives, giving system builders the flexibility to integrate either SAS or SATA devices while slashing the costs associated with supporting two separate interfaces. As the next generation of SCSI, SAS bridges the parallel technology gap in performance, scalability and affordability.

Multiple layers of compatibility

- **Physical layers**

The SAS connector is a universal interconnection that is form-factor compatible with SATA. It allows SAS or SATA drives to plug directly into a SAS environment for mission-critical applications with high-availability and high-performance requirements or lower-cost-per-gigabyte applications such as near-box storage.

SATA connector signals are a subset of SAS signals that enable the compatibility of SATA devices and SAS controllers. SAS drives will not operate on a SATA controller and are keyed to prevent any chance of plugging them in incorrectly.

In addition, the similar SAS and SATA physical interfaces enable a new universal SAS backplane that provides connectivity to both SAS drives and SATA drives. This eliminates the need for separate SCSI and ATA drive backplanes. This consolidation of designs greatly benefits both backplane manufacturers and end users by reducing inventory and design costs.

- **Protocol layer**

SAS consists of three types of protocols, each of which is used to transfer different types of data over the serial interface, depending on which device is being accessed. Serial SCSI Protocol (SSP) transfers SCSI commands, and SCSI Management Protocol (SMP) sends management information to expanders. Meanwhile, SATA Tunneled Protocol (STP) creates a connection that allows transmission of the SATA commands. By including all three of these protocols, SAS provides seamless compatibility with today's existing SCSI applications, management software and SATA devices.

This multi-protocol architecture support, coupled with the compatibility of SAS and SATA's physical connection, allows SAS to operate as the universal interconnection for both SATA and SAS devices.

Benefits of compatibility

SAS and SATA compatibility offer a number of benefits to system builders, integrators and end users.

System builders can now leverage the universal SAS/SATA connection to deploy common backplanes and common connector and cabling devices. Upgrading from SATA to SAS is as simple as replacing the disk drives. With parallel technologies, upgrading from ATA to SCSI means replacing backplanes, connectors, cables and drives. Other

cost-saving benefits of compatibility include simpler validation and inventory management.

VARs and system integrators will be able to easily configure custom systems by simply installing the appropriate disk drive. This is because working with dissimilar technologies and using specialized connectors and different cabling will no longer be necessary. Moreover, the added price/performance flexibility will better enable VARs and system integrators to differentiate their products.

For end users, SAS and SATA compatibility offers a new level of price/performance flexibility. SATA drives will suit those requiring the best price advantage for servers and storage deployments, while SAS drives will deliver the highest performance, reliability and software management compatibility. The ability to upgrade from SATA to SAS drives without having to buy a new system will greatly simplify the purchasing decision, future-proof system investment and reduce the total cost of ownership.

Committee collaboration

On January 20, 2003, the SCSI Trade Association (STA) and the Serial ATA (SATA) II Working Group announced a partnership to enable SAS system-level compatibility with SATA hard disk drives.

This collaboration, as well as cooperation among storage vendors and standards committees, will further define compatibility guidelines - a move that will help system builders, IT professionals and end users more finely tune their systems to optimize application performance and reliability and reduce total cost of ownership.

The SATA specification reached revision 1.0 in 2001, and SATA products are available today from a variety of manufactures. The SAS specification revision 1.0 is targeted for release in early 2003, with product availability in the first half of 2004.

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By Paul Griffith

So how is a Serial ATA drive different?

Serial ATA or SATA drives are a new standard in HDD/motherboard interfaces and are touted as the next mainstream storage interface. SATA drives are fast with the first generation having a volume of 150 MB/sec compared to Parallel ATA (PATA) drive's 100 MB/sec. Generation two (coming out in 2005) is predicted to go up to 300 MB/sec. This is also better than USB interfaces at 60 MB/sec and generation two will be better than current firewire volume of 200 MB/sec.

In December 2001, the SCSI Trade Association (STA) board of directors voted to define the marketing requirements for the Serial Attached SCSI specification and to assume the responsibility for promoting the technology to the industry. Both Serial Attached and Parallel SCSI will be defined, developed and standardized side by side for the benefit of STA members and the storage I/O industry as a whole. The following FAQ describes each technology in its present form and forecasts future plans.

Serial Attached SCSI - FAQ

1. What is Serial Attached SCSI?

Serial Attached SCSI is the logical evolution that satisfies the data center requirement of scalability, performance, reliability and manageability, while **leveraging a common electrical and physical connection interface from Serial ATA**. This provides users with unprecedented choices for server and storage subsystem deployment.

2. Why is Serial Attached SCSI being developed?

Serial Attached SCSI is being developed to address anticipated I/O and direct attach storage requirements. It will provide universal interconnect with Serial ATA, while offering logical SCSI compatibility along with the reliability, performance and manageability of Parallel SCSI.

3. What is the difference between Serial Attached SCSI and Parallel SCSI?

Parallel SCSI is a proven enterprise level technology for I/O and device requirements with more than a twenty-year history of reliability, flexibility and robustness. Parallel SCSI has limited device addressability as well as certain physical limits associated with the nature of its distributed transmission line architecture (performance and distance), plus large connectors that make it unsuitable for certain dense computing environments.

Serial Attached SCSI will leverage the proven SCSI technologies that customers expect in data center environments, providing robust solutions and generational consistency. It will be based on a serial interface, allowing for increased device support and bandwidth scalability, reducing the overhead impact that challenges today's SCSI environments. It will provide easy solutions for systems with simplified cable routing. It will also utilize the Serial ATA development work on smaller cable connectors, providing customers a downstream compatibility with desktop class ATA technologies.

Finally, this simplified routing will enable a new generation of dense devices, such as small form factor hard drives, which will enable storage solutions to scale where traditional parallel SCSI cannot, due to cabling and voltage challenges.

4. When will Serial Attached SCSI solutions be available?

Development components such as HBAs, RAID controllers, enclosures, drives and expanders will be available for evaluation in late 2003, with solutions in production beginning in 2004.

5. What are Serial Attached SCSI expanders and what function do they provide?

Expanders are simple virtual circuit switches that provide scalability of basic Serial Attached SCSI configurations. There are edge expanders typically enclosed in the drive enclosure, and fan-out expander devices for large configurations. Each expander can address 64 devices with a maximum cascade configuration of 4096 total devices in a Serial Attached SCSI domain. These expanders would be configured between the Serial Attached SCSI drives and the RAID controller.

6. Will the industry be able to sustain four different interfaces Serial ATA, Fibre Channel, Parallel SCSI and Serial Attached SCSI?

By leveraging leading OEM and IHV investment in current interface standards, the ability to produce and deliver Serial Attached SCSI solutions will be very achievable. For customers, it also provides the best investment protection by combining the benefits and reliability of SCSI with the universal interconnect of desktop class Serial ATA solutions.

7. Is Serial Attached SCSI development an effort to create an interface or a new device?

It is both an interface and for devices, which will be developed once the specification is final. When Serial Attached SCSI is fully developed, standardized and available to the market, customers will be able to purchase end-to-end solutions addressing their enterprise requirements.

8. What are the end user benefits of Serial Attached SCSI?

Key customer benefits include: enterprise class robustness, investment protection in compatible SCSI software and the choice of direct-attach storage devices (Serial ATA or Serial Attached SCSI). In addition, longer cabling distances, smaller form factors and greater addressability will all lead to a new level of flexibility when deploying mainstream data center servers and subsystems. Since Serial Attached SCSI is based on the foundation of the industry-leading Parallel SCSI specification, reliability and peace of mind will satisfy users' needs for continuity in the data center.

9. Is Serial Attached SCSI complementary to or competitive with Parallel SCSI?

Serial Attached SCSI is complementary to Parallel SCSI. Parallel SCSI is a proven enterprise class technology for I/O and device requirements. Serial Attached SCSI will leverage the proven SCSI technologies that customers expect in data center environments, providing robust solutions and generational consistency. It will be based on a serial interface, allowing for an increased number of devices and future bandwidth scalability. Simplified cable routing will provide easy solutions for systems. It will also utilize the Serial ATA development work on smaller cable connectors, providing customers a downstream compatibility with desktop class Serial ATA. Finally, this routing will enable a new generation of dense devices, such as small form factor hard drives, enabling storage solutions to scale externally.

10. Is Serial Attached SCSI complementary to or competitive with Fibre Channel?

Initial implementations of Serial Attached SCSI will have support for greater than 128 addresses, and provide dual ported device support. Fibre Channel will continue to evolve as the interconnect and device solution for large enterprise storage configurations, offering up to 16 million addresses, and longer cabling distances of ten kilometers. Serial Attached SCSI (SAS) is a **more bounded configuration that will initially be targeted at direct-attach storage environments, server, device attachment to RAID controllers, and bounded out-of-box connection schemes.**

11. Is Serial Attached SCSI complementary to or competitive with Serial ATA?

Serial Attached SCSI complements Serial ATA by adding device addressing (scalability), and offers higher reliability, manageability and data availability services, along with logical SCSI compatibility. It will continue to enhance these metrics as the specification evolves, including increased device support and better cabling distances. **Serial ATA is the best choice for desktop, servers and networked storage where price is the primary selection factor.** Most importantly, these are complementary technologies based on a universal interconnect, where Serial Attached SCSI customers can choose to deploy cost-effective Serial ATA in a Serial Attached SCSI environment. In summary, customers requiring the best price advantage for server and storage deployments should choose Serial ATA and customers requiring maximum performance, reliability and software consistency should select Serial Attached SCSI.