

Technology Paper

Enterprise-optimised 6-Gb/s SAS rivals Fibre Channel Performance and Scalability at Lower Cost

Introduction

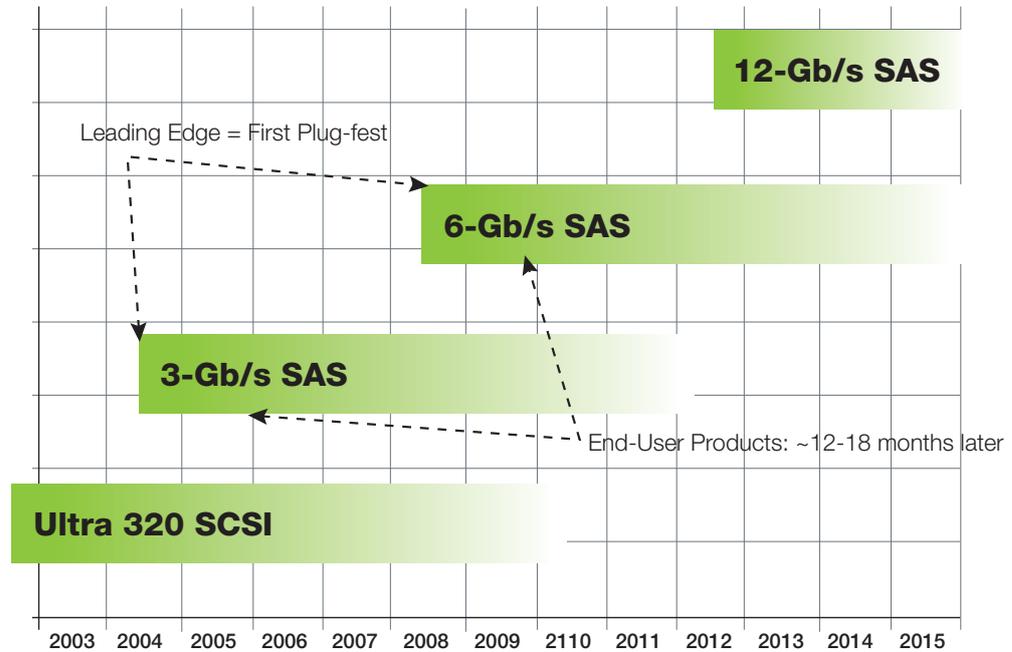
In just a few short years Serial Attached SCSI (SAS) has fundamentally altered the enterprise storage landscape. Building on the rock-solid reliability and robust command set of its parallel SCSI predecessor, SAS has raised the storage bar with an unprecedented combination of performance (3-Gb/s transfer rate), scalability (thousands of devices in one domain) and flexibility (compatibility with SATA).

In Q3 2005, 3-Gb/s SAS systems entered the market, and by 2007 they were shipping in large quantities. SAS has supplanted parallel SCSI as the direct-attached SCSI interface of choice throughout the enterprise; indeed, it was one of the fastest interface transitions in market history.

This rapid transition relied on the close working relationship between the SCSI Trade Association (STA) and the T10 Committee. The STA focuses on identifying SCSI's marketing requirements and providing the forum to reach a consensus on features and benefits included in the SCSI roadmap, while the role of the T10 Committee is to develop standard specifications to make it possible for those features and benefits to be implemented in commercial products.

The T10 Committee developed the new SAS-2 technical specification (SAS protocol and physical interface enhancements for transporting SCSI over serial links at up to 6 Gb/s), and the STA has given the marketing name "6-Gb/s SAS" to this new industry standard (see Figure 1).

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Figure 1. SAS Roadmap

With the recent introduction of this new SAS-2 standard specification, SAS is once again poised to rewrite the rules for enterprise storage, this time setting its sights on the data centre’s premier interface, Fibre Channel (FC) .

According to the STA, “6-Gb/s SAS has many enhancements beyond 3-Gb/s SAS. It has more bandwidth per connection, greater scalability and enhanced features. 3-Gb/s SAS usage models will be preserved in 6-Gb/s SAS, along with the retention of 1.5-Gb/s and 3-Gb/s SAS/SATA compatibility. There are many other targeted improvements beyond first-generation 3-Gb/s SAS, assuring enterprise storage users that SAS technology will continue to meet their needs.”

While its blazing 6-Gb/s transfer rate (double that of the previous generation) is the most obvious attribute of the SAS-2 specification, a comprehensive suite of additional enhancements enables 6-Gb/s SAS to rival FC solutions in a variety of enterprise storage environments - at significantly lower cost. Moreover, 6-Gb/s SAS does so whilst retaining compatibility with earlier SAS and SATA hard drives.

Key 6-Gb/s SAS features include standardised expander zoning and expander self-discovery,

which enable more secure and efficient scalability when deploying the enormous number of drives increasingly found in high-end enterprise arrays. Factor in the faster throughput, longer maximum cable lengths and greater signal integrity, and it becomes clear that 6-Gb/s SAS is a compelling, cost-effective rival to FC in many network storage applications.

More Storage, Less Expense

Satisfying the enterprise’s relentless hunger for greater storage capacity and faster throughput poses a difficult challenge for today’s storage professionals, who are also expected to cut costs whenever possible. FC has long been the preferred interface for a variety of network storage architectures used in enterprise data centres:

- SAN (storage area network)
- NAS (network attached storage)
- JBOD/RAID (just-a-bunch-of-discs/redundant array of independent discs)

Of course, FC is also known for coupling its remarkable throughput and scalability with daunting costs. Beyond the substantial investment required for the infrastructure itself, Fibre Channel solutions also entail complex deployment and

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6-Gb/s SAS: Performance, flexibility and value in affordable and easy-to-manage storage environments	
Feature/Function	Benefit
6-Gb/s transfer rate	Enables enterprise-class performance at 2x the throughput of today's SAS/SATA environments
Standardised expander zoning	Provides common infrastructure with seamless scalability
Expander self-discovery	Provides common infrastructure with seamless scalability
10-M cable length	Extends connectivity by 66 per cent, supporting networked storage expansion beyond a single rack
Greater signal integrity with SSC	Enables 6-Gb/s SAS drives to be installed in close proximity to one another without compromising data integrity
Cost-effective simplification	Simplified connectivity with standardisation on mini-SAS connectors
Investment protection	Retains compatibility with earlier SAS/SATA hard drives and SCSI software/middleware
Management efficiencies	Uses existing IT SCSI expertise

Figure 2. Features and Benefits of 6-Gb/s SAS

management procedures that require highly specialised (and expensive) expertise not found in many IT departments. Hence, FC has generally been limited to enterprises with the needs (and deep pockets) to justify its use.

Devices with 6-Gb/s transfer rates deliver greater performance, flexibility and value in traditional direct-attached applications such as internal server storage. But more importantly, 6-Gb/s SAS storage solutions now offer an affordable, easy-to-manage alternative to FC in network storage environments. Achieving this capability required several key enhancements to the SAS standard developed by the T10 Committee¹.

These new key enhancements are detailed in the following sections:

Standardised Expander Zoning

Standardised expander zoning provides common infrastructure with seamless scalability. While the SAS-1 specification theoretically enabled enormous addressability (up to 128 expanders, each supporting up to 128 SAS devices), in practice even a few hundred storage devices or subsystems required some type of zoning scheme to assign storage domains when used with multiple hosts.

This capability, known as expander zoning, was not formally defined in the SAS-1 standard. Therefore, this zoning could be implemented in a variety of vendor-specific, and frequently inconsistent, ways that result in zoning incompatibilities leading to inaccessible storage and/or limit customers to single-vendor solutions. To eliminate such incompatibilities, standardised expander zoning is part of the SAS-2 specification and a required feature in all 6-Gb/s SAS expanders. Furthermore, expanders can now support up to 256 devices.

Also, 6-Gb/s SAS expanders support secure zones, similar to fibre channel SAN zones. Using *denial of service* and *device access control by zone* technologies, networked storage can be grouped so that multiple hosts may talk to the expander, but only see a specified subset of the storage devices. This provides greater data security and makes storage easier to manage in the multi-drive network storage environments typical of enterprise data centres.

¹ The T10 Committee (www.t10.org) is part of the International Committee on Information Technology Standards (INCITS) and is accredited by, and operates under, rules approved by the American National Standards Institute (ANSI). These rules are designed to ensure that voluntary standards are developed by the consensus of industry groups such as the SCSI Trade Association (SCSITA, www.scsita.org).

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Expander Self-Discovery

Expander self-discovery simplifies administration, while doubling storage scalability. Under the SAS-1 standard, connecting devices to the expanders was a host-based process. As long as the number of SAS drives in the storage pool was relatively small, this discovery scheme was reasonably efficient. But in network storage environments, where massive numbers of drives are typically employed, host-based discovery resulted in increased SAS messaging traffic between hosts and expanders, and more time was needed to initialise systems.

The SAS-2 standard resolves this issue by shifting the SAS discovery process from the host to the expander. Enabling 6-Gb/s SAS expanders to perform device discovery themselves, automatically and in parallel, makes the provisioning of large systems of SAS drives both faster and easier to manage. This expander self-discovery technology plays a pivotal role in ensuring seamless scalability as network storage needs (and storage device quantities) inevitably grow.

6-Gb/s SAS: Optimised for the Enterprise

While the impressive capabilities of 6-Gb/s SAS in network storage environments clearly stem from the inclusion of standardised expander zoning and expander self-discovery technologies, they are not the only aspects of the SAS-2 standard that make 6-Gb/s SAS so effective in enterprise storage arrays. Indeed, 6-Gb/s SAS incorporates a variety of enterprise-centric features, including:

6-Gb/s Transfer Rate

The 6-Gb/s transfer rate enables rock-solid enterprise-class performance at twice the throughput of today's SAS or SATA environments. Higher throughput is always a desirable feature in any storage solution, but it is particularly important in enterprise data centres, where drives can be accessed repeatedly by multiple initiators. With double the transfer rate of its 3-Gb/s SAS predecessor, 6-Gb/s SAS delivers the speed necessary to keep up with the demands of high-traffic network storage environments.

Delivering performance that is competitive and significantly less expensive than FC storage solutions, 6-Gb/s SAS also offers a more

compelling performance/price value proposition than costly solid state drives (SSDs).

10-Metre Maximum Cable Length

A 10-metre maximum cable length extends connectivity by 66 per cent, supporting networked storage expansion beyond a single rack. 6-Gb/s SAS delivers a remarkable 100 per cent boost in transfer rate, while also enabling the use of longer connecting cables (up to 10 metres: an increase from the 6-metre cables supported by 3-Gb/s SAS). Achieving this improvement in throughput and maximum cable length required the use of decision feedback equalisation (DFE) technology.

DFE counteracts the signal attenuation effects that arise from greater cable lengths by de-emphasising lower frequency components at the transmitter and selectively boosting higher frequency components on the receiving end. This enables the use of 10-metre cables with no loss of signal integrity, while still maintaining compatibility with existing six-metre cables.

This 66 per cent increase in maximum cable length pays significant dividends in the data centre, enabling far greater flexibility in terms of wide-scale storage system deployment and installation. This cable extension provides the flexibility to expand your network-attached storage beyond the limits of a single rack, using a 10-metre cable while ensuring the integrity of the data.

Spread Spectrum Clocking

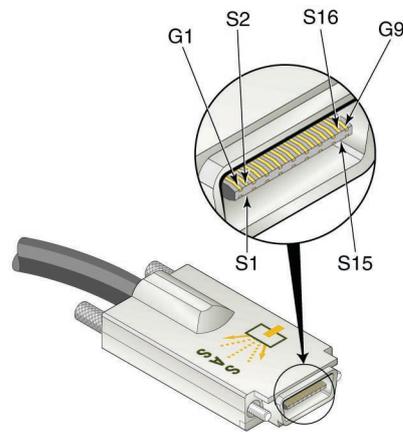
6-Gb/s SAS doubles the data frequency of 3-Gb/s SAS; this may result in a loss of cabinet shielding efficiency due to the shorter wavelengths of the signals.

To combat this change in frequency, 6-Gb/s SAS employs spread spectrum clocking (SSC), a slow-frequency (30–33 KHz) modulation of the data frequency. By reducing the peak values and spreading the radiated emissions over a broader range of frequencies, SSC helps to reduce EMI-related issues.

Simplified Connectivity

Simplified connectivity standardises on mini-SAS connectors for cost-effective SAS solutions. To simplify cabling options and to streamline integration, 6-Gb/s SAS eliminates the expensive InfiniBand-style (SFF-8470, Figure 3) connector

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SFF-8470 Multilane 4x Connector
(icons on each end)

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Figure 3. Costly InfiniBand-style connector used by 3-Gb/s SAS

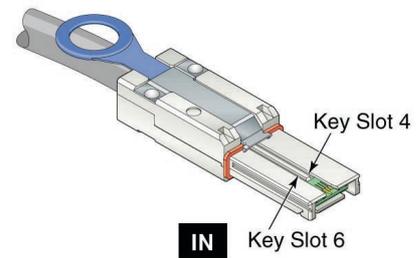
used by 3-Gb/s SAS and relies solely on the mini-SAS connector for both internal (SFF-8087) and external (SFF-8088, Figure 4) connectivity.

Standardising on mini-SAS connectors is particularly appropriate for the data centre, where these connectors are becoming increasingly commonplace through their use on small form factor (SFF) 2.5-inch hard drives.

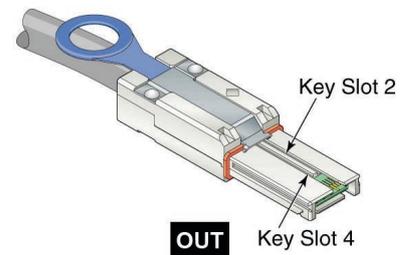
Investment Protection with Backwards Compatibility

Given the numerous technical advancements that the new SAS-2 specification incorporates, it may be surprising to learn that 6-Gb/s SAS maintains full 1.5-Gb/s and 3-Gb/s SAS/SATA compatibility. To further ensure seamless interoperability, existing SCSI software and middleware compatibility is also retained.

Such compatibility is key to ensuring that the enterprise's current installed base of SAS storage solutions will continue to maintain its value as the transition to 6-Gb/s SAS gains momentum.



SFF-8087 Mini Multilane 4x Connector
(icons & keys on both ends)



SFF-8088 Mini Multilane 4x Connector
(icons & keys on both ends)

Graphics copyrighted by SCSI Trade Association, courtesy of Molex.

Figure 4. Compact, cost-effective, mini-SAS connectors used by 6-Gb/s SAS

Conclusion

With growing pressure throughout data centres to cut spending while keeping pace with the inexorable demand for more storage capacity and speed, the steep cost and complexity of fibre channel solutions have become increasingly problematic. The arrival of 6-Gb/s SAS provides a compelling, cost-effective alternative, boasting performance and scalability that rivals fibre channel. 6-Gb/s SAS delivers a more economical and far simpler alternative to purchase, install and maintain for business sustainability.