Serial Attached SCSI Cables and Connectors
SCSI Trade Association White Paper

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Introduction

Serial Attached SCSI (SAS) was defined in late 2001 by a working group made up of leading industry members, then was transferred to the ANSI T10 Technical Committee for development and standardization. In late 2003, it became an ANSI standard. The first generation will operate at a speed of 3 Gb/sec and the second generation, to be introduced in approximately 2007, will operate at 6 Gb/sec. In the process of defining and standardizing the technology, the T10 technical and SFF committees have defined cables and connectors to support the many different SAS-based system topologies that can now be developed. These cables and connectors are available today from many suppliers listed on the SCSI Trade Association website (http://www.scsita.org). Additional connectors are also in development that will provide higher I/O density. This white paper summarizes these solutions and provides direction for the connectivity implementation of SAS-based systems.

Serial Attached SCSI Advantages

SAS is the next-generation storage interface standard for SCSI-based systems, designed to replace the SCSI parallel interconnect cable with a much smaller, more flexible serial design. SAS is a point-to-point connectivity storage system architecture that has many advantages over its parallel SCSI predecessor:

- Larger, more dense disk arrays
- Longer cable reach
- Simpler cable routing and better system airflow
- Faster data rates and overall superior system performance
- More devices per controller
- Support for both SAS and Serial ATA (SATA) disk drives
- Simpler and more extensive system scalability (supported with SAS expanders)
- More flexible system topologies
- Support for dual-port SAS disk drives for system redundancy

SAS Cable and Connector Applications

The flexibility of SAS interconnect schemes facilitates many different system-level configurations such as workstations, blade servers, external storage arrays, SAS switches (using SAS expanders) and host bus adapters (HBAs). SAS also supports SATA disk drives. SAS interconnect products support these configurations with the following versions:

- Disk-drive receptacles
- Backplane and flush-mount connectors that mate with disk-drive receptacles
- Intra-enclosure, single-lane cables and connectors
- Intra-enclosure, multi-lane cables and connectors
- Inter-enclosure, multi-lane cables and connectors

Basic Cable and Connector Descriptions

Cable wiring

Cabling that supports high-bandwidth differential signaling is generally constructed using ‘twin-axial’ (or ‘twin-ax’) wiring. This cabling is available in different conductor wire gauges and constructed for various

applications, such as single-lane twin-axial for internal, multi-lane twin-axial for internal and multi-lane twin-axial for external applications.

High quality twin-axial cables need to be manufactured by reputable suppliers to ensure assembly and electrical quality. It is not recommended that cables be constructed on the bench top.

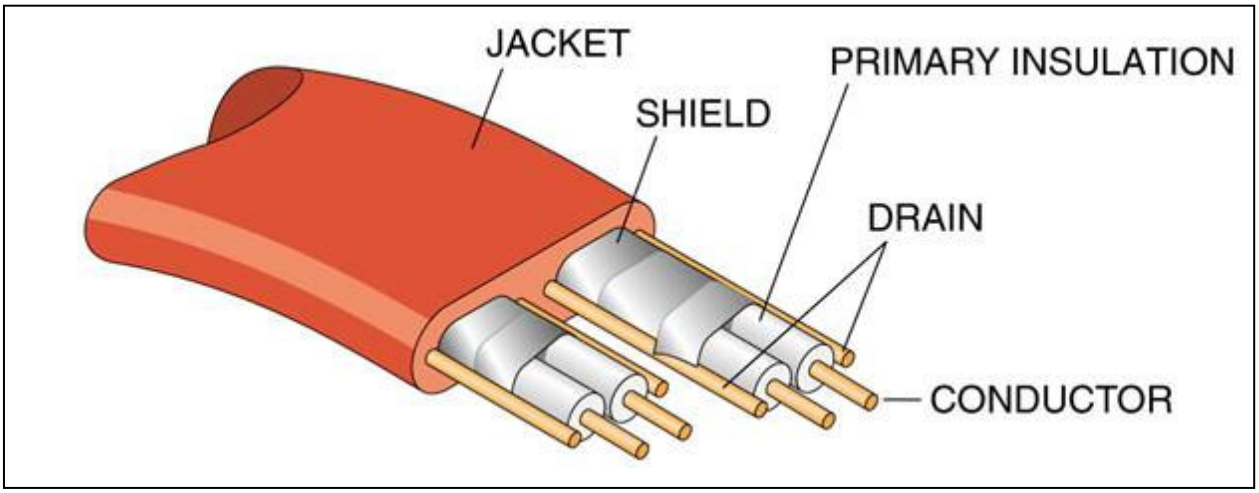

Figure 1: Example of single lane twin-axial cable construction

Twin-ax cabling is a type of coax-like transmission cable that supports differential signaling. Each electrical communication channel consists of two conductors, each jacketed by a primary insulator. This pair is surrounded by an outer conductive shield – braid or foil. 'Drain' wires are normally used with precision-wound, spiral-wrap aluminum foil shielding to guarantee continuity of the shield. The entire assembly (two conductor pairs for single-lane cable, eight conductor pairs for four-lane cable) is covered with an insulating and protective outer layer (usually PVC) that provides flexibility and mechanical protection for the inner parts. Historically, versions of twin-ax have been used in some special data-communication applications such as older IBM* terminals and military communications.

Figure 1 illustrates the construction of a single-lane (two-pair) twin-ax cable. Cable for four-lane applications is similar, but contains eight individually shielded signal pairs that are twisted into a round bundle that is jacketed with a protective insulator. This is used with the SFF-8470 (SFF-nnnn are SFF committee designators) style enclosure-to-enclosure cable assemblies discussed later.

Larger gauge conductors provide less loss per distance but are mechanically less flexible. Twenty-four-, 26-, 28- and 30-gauge conductors are available. Minimum conductor pair skew is critical for the most favorable propagation of high-speed serial signals. Concise control of the shielding application in the cable and cable assembly processes is a prime factor in producing high-quality cables. For instance, impedance discontinuities caused by unraveled shields or broken shield connections at the connector will cause reflected signal energy. Excessive conductor skew or discontinuous shielding will cause crosstalk, signal loss, and electromagnetic interference (EMI) – all significant problems at SAS data rates.

SAS/SATA drive receptacles

SAS and SATA disk-drive receptacles are standardized by SFF-8482. They are designed to reinforce the connectivity supported by their correlating standards. SAS host controllers (initiators) and expanders may support both SAS and SATA disk drives, but SATA controllers can only support SATA disk drives. SAS disk-drive receptacles are therefore keyed to prohibit them from mating with SATA cable or backplane plugs. SAS cable and backplane plugs will mate with either SAS or SATA drives.

SAS disk drives are generally 'dual-port', providing a redundant connection to the drive for more fault-tolerant systems. The pins for the second port are located on the opposite side of the receptacle from the side that provides primary SAS/SATA connection (located where the keying feature would be on a SATA plug). A SAS or SATA disk-drive connector provides an array of 15 pins for power and seven pins for each high-speed serial data connection. Many drives also provide the four-pin legacy power connector for non-backplane applications, but power cable adapters (four-pin legacy to 15-pin SAS/SATA power plugs)

are readily available for those drives that do not provide that connector. The 'data' portion of the connector provides two pins each for transmit and receive pairs, with each pair straddled by signal ground pins. The ground pin between pairs is shared (ground-signal-signal-ground-signal-signal-ground). Figure 2 below shows both SAS and SATA plugs with cables and receptacles.

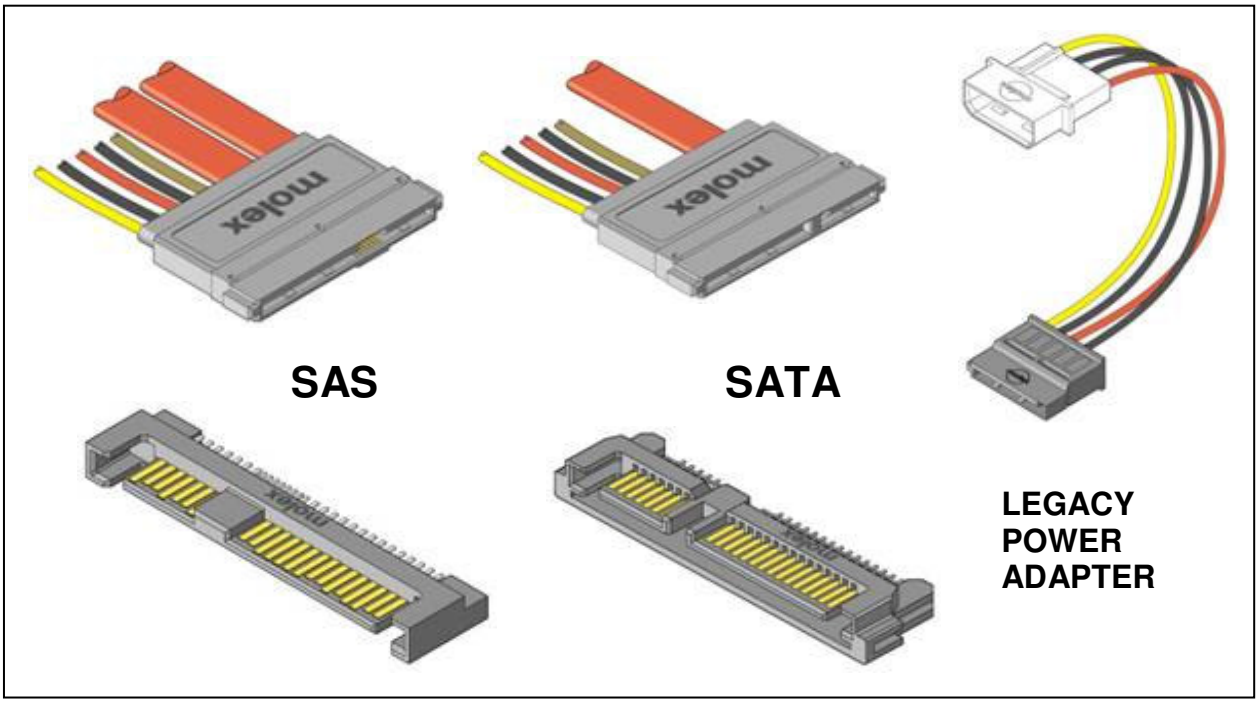

Figure 2: SAS/SATA disk drive receptacles and mating cables

The locations of these connectors are standardized for 5.25", 3.5" and 2.5" disk drives by SFF standards to enable backplane and flush-mount systems to mechanically support disk drives from all suppliers.

Backplane and flush-mount disk-drive connectors

There are a variety of PCB (printed circuit board)-mounted connectors available for connecting directly to a SAS or SATA disk drive. Backplane connectors (Figure 3) are available in through-hole mount, surface mount and press-fit with optional heights (standard and extended). Through-hole mount and press-fit connectors are generally used in backplanes to withstand the inherent mechanical stresses. SAS connectors are also available for mounting disk drives flush to the PCB such as in blade-server applications, as shown in Figure 4. The robust 'blind-mate' design of the mating connectors ensures that drives mounted in carriers seat reliably and easily in drive cages that support swappable drives.

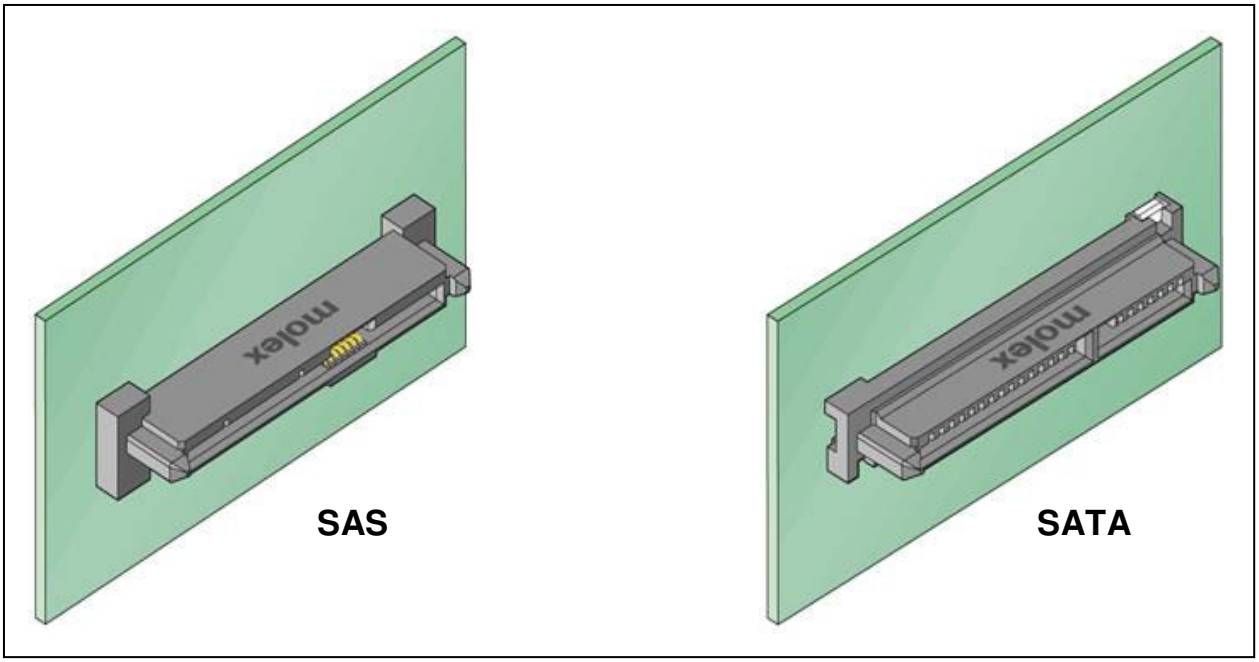

Figure 3: Example SAS and SATA backplane connectors

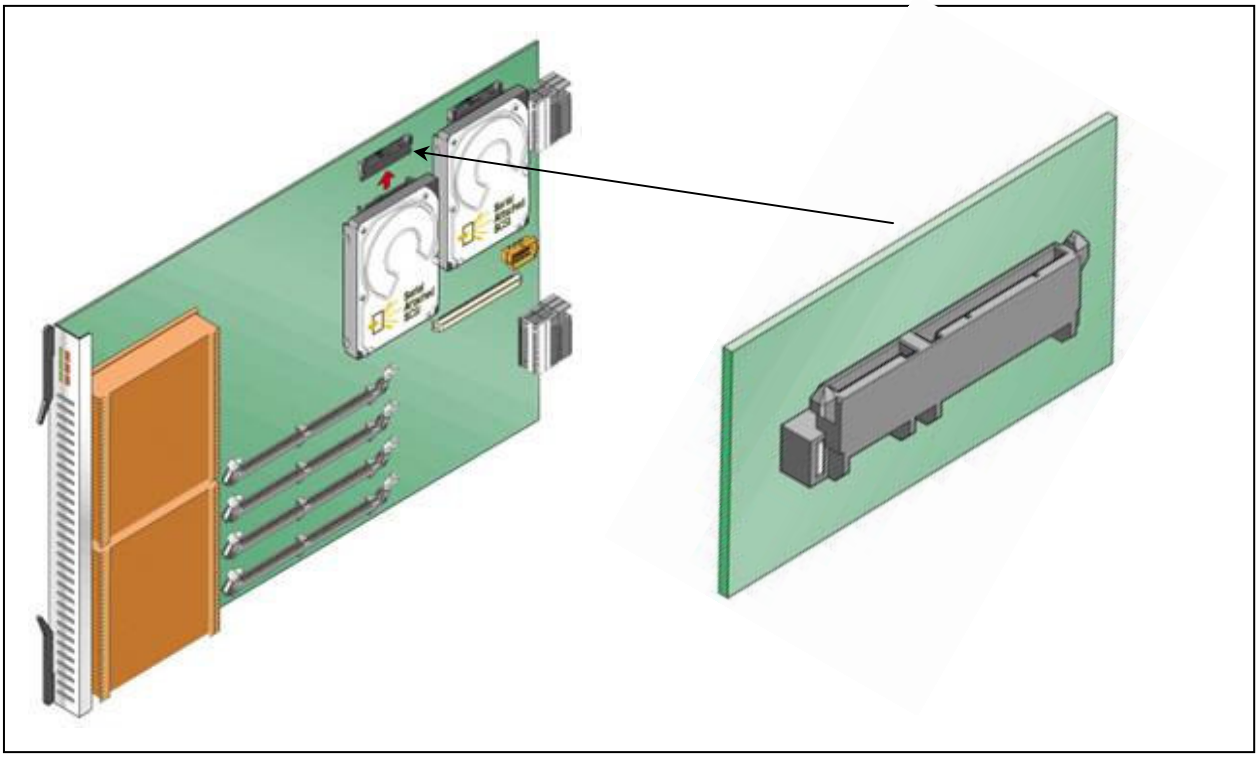

Figure 4: Flush-mount SAS drive connector

Contact Sequencing

To facilitate insertion of a drive into a powered system (‘hot insertion’), the backplane connector is designed with a three-level contact engagement sequence. By using a nominal offset of 0.50mm on key contact positions, the contact engagement of electrostatic discharge (ESD), ground and power pre-charge are sequenced to eliminate the possibility of damage to the drive or backplane. Full power and signal contacts are the last connections to be established.

SAS/SATA single-lane intra-enclosure cables and connectors

For applications such as desktop and tower servers, single-lane cabling is often the most optimal way to connect on-motherboard SAS controllers or host bus adapters to SAS disk drives. This scheme is inexpensive and provides the configuration flexibility to mount the disk drives nearly anywhere in the system. Power can be provided to the drives using legacy ATX four-pin power connectors if the drive supports this. Figure 2 shows examples of single-lane SAS and SATA cable assemblies. Single-lane cables that connect SATA host controllers to SATA drives can be up to one meter in length, but SAS cables can be longer since SAS signaling supports higher interconnect loss than SATA. SAS expanders and initiators that support direct connection to SATA drives have made special accommodations (primarily lower receiver sensitivity) to be able to support SATA across interconnects that are more 'lossy' than SATA-compliant interconnects.

Host-side single-lane PCB-mount connectors are available in surface mount, through-hole, right-angle and straight configurations. Figure 5 shows examples of single-lane cables and connectors. These connectors generally provide connection for the seven-pin data interface only since power for the drives is usually provided directly from the power supply.

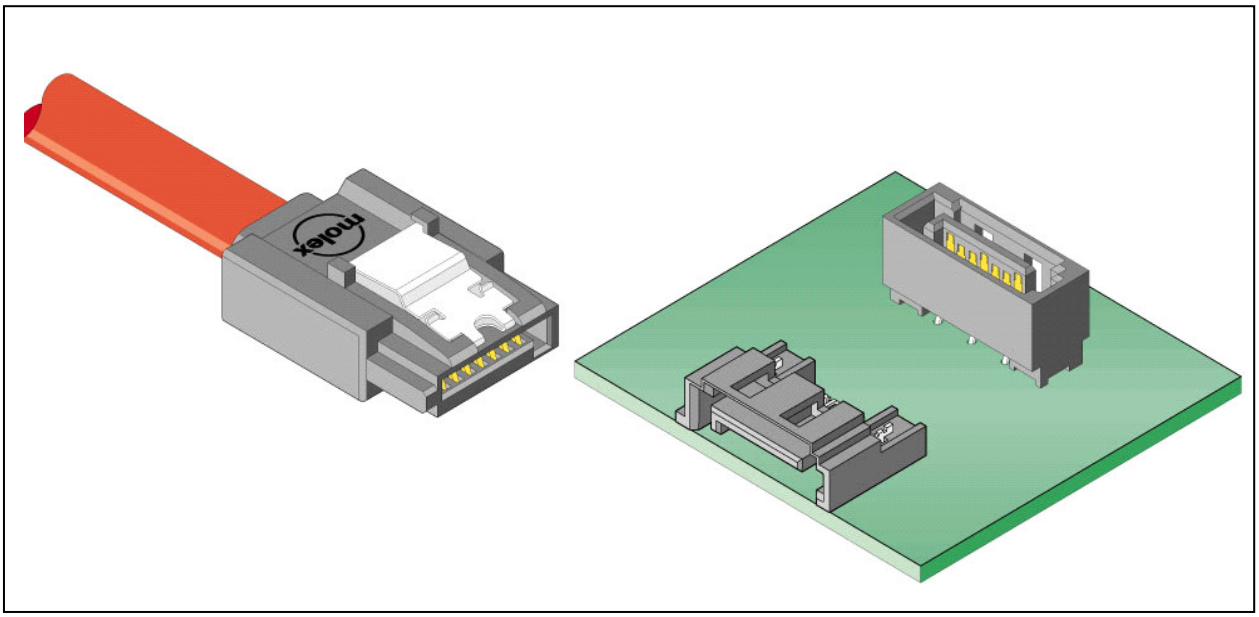

Figure 5: SAS Intra-enclosure single lane cables and connectors

Note that these single-lane connector and cable schemes do not support the dual-port feature of SAS drives. Generally, only SAS backplane plugs support this feature since storage redundancy is usually coincident with support for drive swapping. There are, however, SAS cable assemblies available with the dual-port features as illustrated in Figure 2.

SAS/SATA multi-lane intra-enclosure cables and connectors

Systems that require interconnection between a SAS host bus adapter and a backplane (with or without expander capability) demand a simple single-assembly multi-lane scheme such as the one shown in Figure 6. Such multi-lane cabling systems can be used either to connect a drive per lane or can be used with an expander on the backplane to aggregate traffic to and from multiple drives. The SFF-8484 cable and connector system provides connectivity for four SAS channels plus five 'sideband' signals used for system management and light emitting diode (LED) control. SFF-8485 (SGPIO) is a standard for the use of those signals. In addition, HBAs and backplanes may each have either a single four-lane connector or multiple single-lane connectors, so cables have been created to accommodate interconnection between all combinations. These are sometimes referred to as 'octopus' or 'quadrapus' cables for obvious reasons.

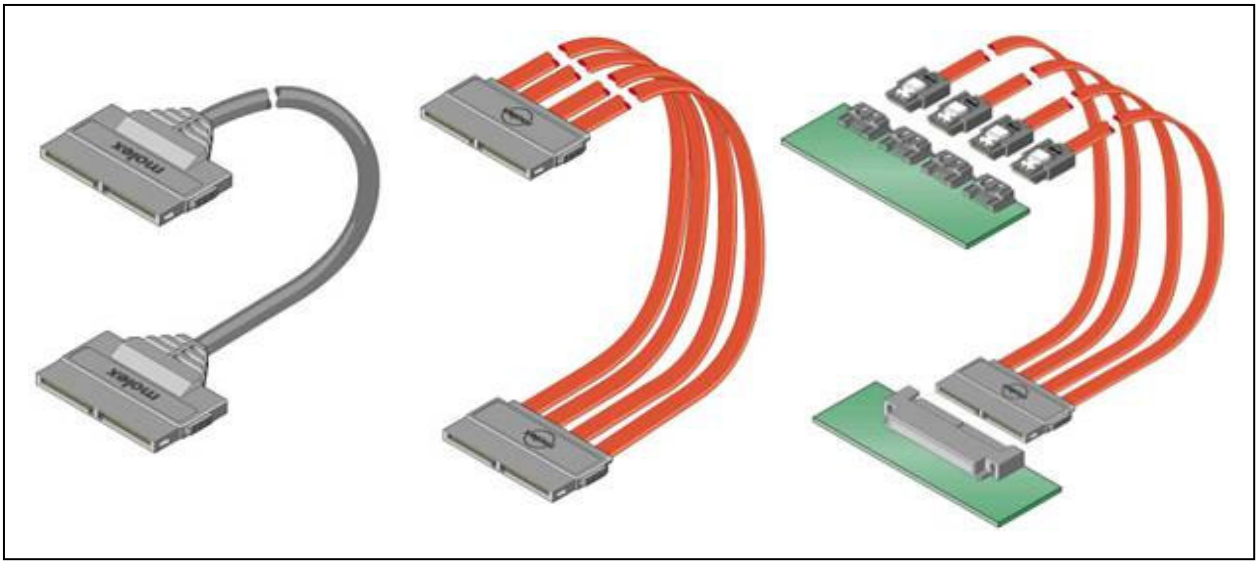

Figure 6: SAS Intra-enclosure multi-lane cables and connectors

External Multi-lane Systems

SAS connections between enclosures are supported with a cable and connector system based on the SFF-8470 scheme first used with InfiniBand**. It supports four lanes of SAS at up to eight meters of length depending on the electrical characteristics of the cable assembly (e.g. wire gauge). Figure 7 shows such a four-lane external cable and PCB connector. The same PCB connector is used on both the host and target sides. Correct connection of host-transmit to target-receive and visa versa is handled by 'flipping' the wiring connections in the assembly from one end to the other during the cable construction.

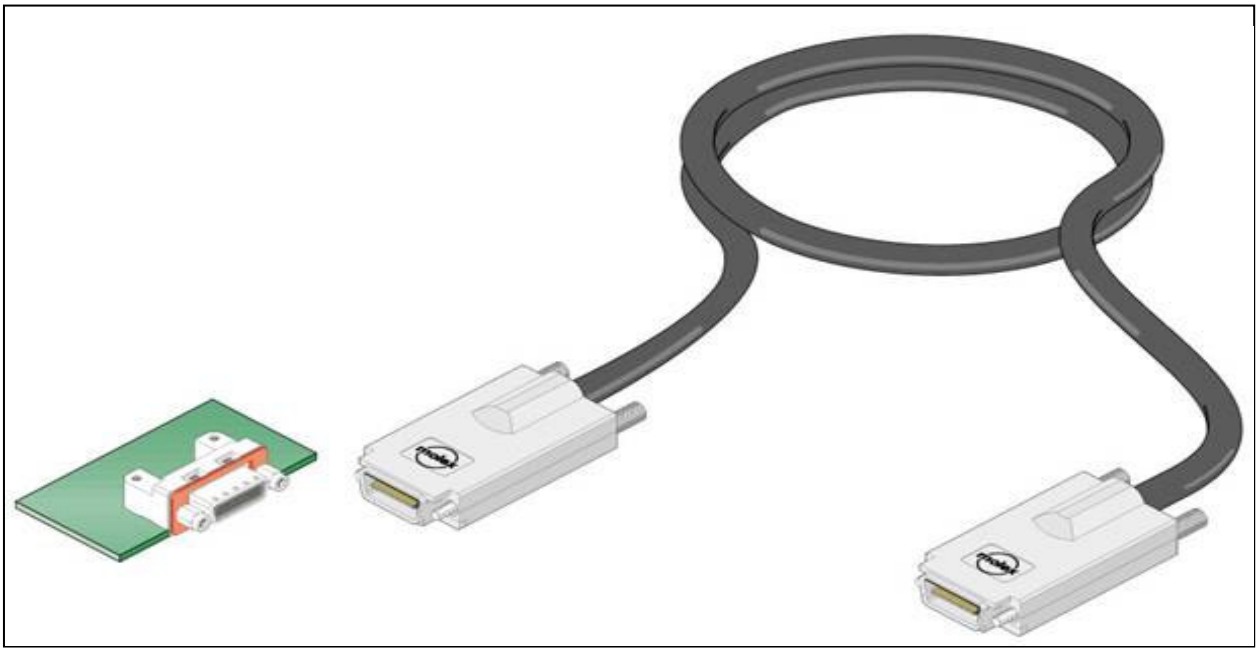

Figure 7: SAS Inter-enclosure (external) multi-lane cable and connectors

This inter-enclosure multilane cabling system is often used with expanders at the target end, which aggregate communications traffic from many disk drives through this single cable assembly. At 3 Gb/sec, each cable can support up to 12 Gb/sec each direction.

On the Drawing Board

The flexibility and scalability of SAS has brought about the demand for even more cable and connector solutions than are currently specified in the SAS standard. At the time of this writing, the T10 Technical Committee and SFF committee are working on new connector schemes that will enable:

- High-density multi-lane intra-enclosure interconnects
- High-density/lower cost external multi-lane interconnects
- High-density board-to-board connector interconnects

In the case of the high-density external connectors, the objective is to be able to connect up to 16 SAS lanes (four lanes per connector/cable) to a PCI card through the I/O panel. These new connectors and associated cable assemblies support current speeds as well as being capable of supporting future speeds.

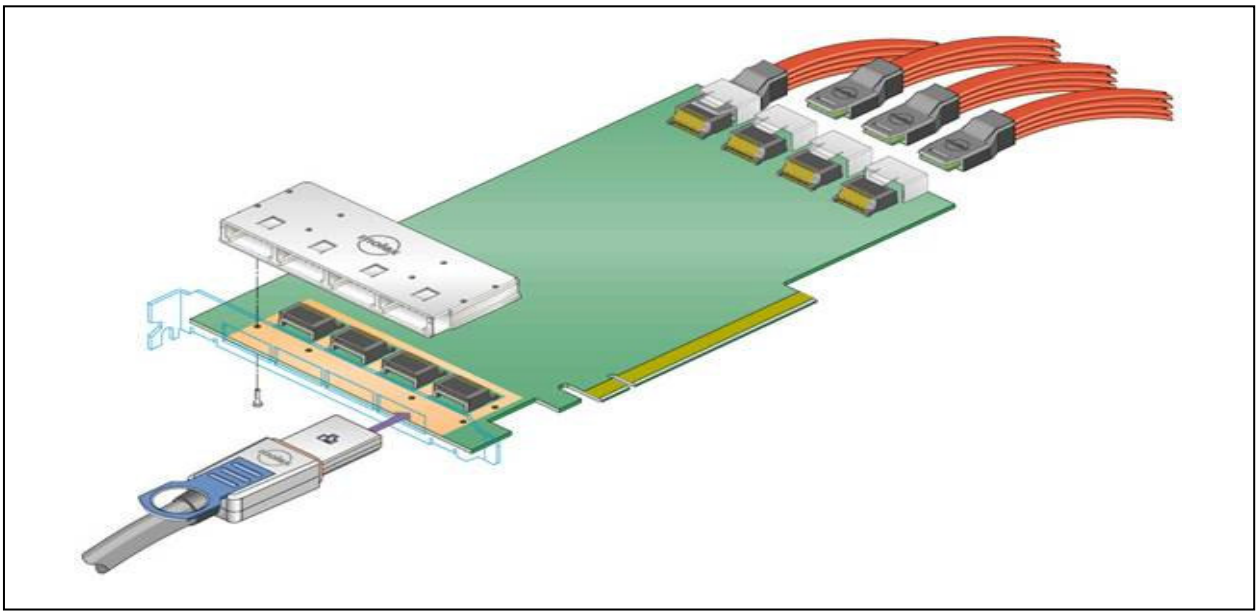

Figure 8: Proposed high-density connector systems

Conclusion:

The ecosystem for SAS cables and connectors is robust and ready for use in production systems. System integrators have access to a broad range of multi-sourced cable/connector solutions to design products that meet the burgeoning demand for advanced storage systems. The SAS innovation treadmill continues to produce high-quality solutions for that marketplace with higher density connectors systems that will support even higher communications speeds. System designers can find contacts for these cable and connector providers by going to http://www.scsita.org.

References:

www.sffcommittee.com

www.t10.org

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