

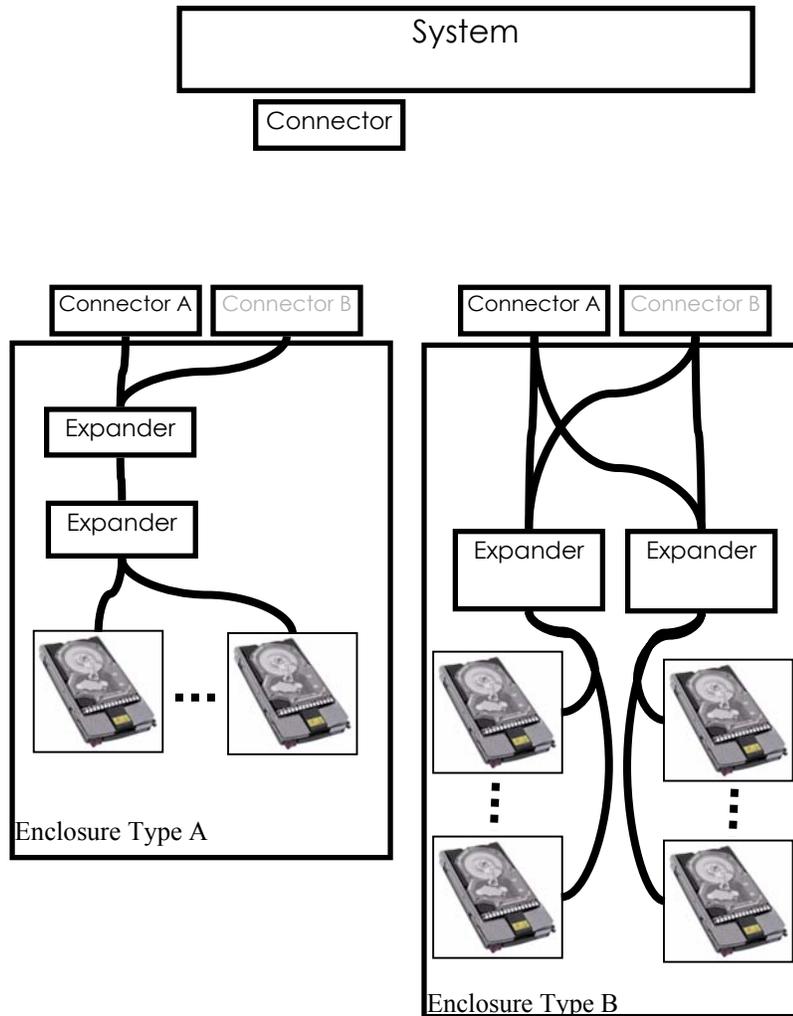
From: Steven Fairchild, HP (steve.fairchild@hp.com)
 Date: 3 March 2005
 Subject: SAS 1.1 External Connector Interoperability

During the last SAS plugfest (November, 2004) sponsored by STA, a couple of interoperability issues were uncovered that are not currently covered by the SAS spec.

Both issues were related to the connectivity available through the external connector on JBOD enclosures.

The first issue is an incompatibility that is created when phys routed to an external connector are attached to different expander and/or end devices within the enclosure (see Figure 1).

Figure 1, Plugfest Configuration



When the System connector was attached to either of the enclosures (from different manufacturers) the devices were properly discovered. Both enclosures were designed to be “daisy chained” to additional enclosures. When enclosures from the same manufacturer were

“daisy chained” (Enclosure type A to Enclosure type A or Enclosure type B to Enclosure type B) the topology was properly discovered. However when enclosures were “daisy chained” to each other (Enclosure Type A to Enclosure Type B or Enclosure Type B to Enclosure Type A) the topology was not properly discovered.

For “daisy chaining” to function, both enclosures defined one connector (assume Connector A for both enclosures) to use Table routing for the phys in the connector and one connector (assume Connector B for both enclosures) to use Subtractive routing for the phys in the connector. This allows the normal SAS routing behavior of chaining Table to Subtractive to create a large expander device set.

Enclosure Type A chose to attach all of the phys within each of its connectors to a single expander. Enclosure Type B chose to attach the phys within each of its connectors to multiple expanders. These two design choices are what caused the interoperability problem. When Enclosure Type A, Connector B is attached to Enclosure Type B, Connector A (Subtractive phys of Enclosure A to Table phys of Enclosure B) a conflict occurs because the expander attached to Enclosure Type A, Connector B has to different SAS Addresses attached to its Subtractive phys. This is an illegal routing configuration, because the expander attached to Enclosure Type A, Connector B cannot determine where to route its Subtractive addresses. Similar routing issues result from the different connection combinations (see Table 1).

Table 1, Connectivity Options

Enclosure A		Enclosure B		Result
Connector A (table routing)	Connector B (subtractive routing)	Connector A (table routing)	Connector B (subtractive routing)	
X		X		Illegal, can't connect Table to Table
X			X	Legal, but failed due to sharing of route table entries in Enclosure A.
	X	X		Illegal, multiple SAS Addresses going to the Subtractive phys of the expander in Enclosure A
	X		X	Illegal, multiple SAS Addresses going to the Subtractive phys of the expander in Enclosure A

From Table 1, the only legal connection Enclosure A, Connector A attached to Enclosure B, connector B had a problem due to a design decision based on the assumption that a connector would only present a single SAS address if it was attached to an expander.

To resolve this interoperability issue, HP would propose the following text (in blue) be incorporated in SAS 1.1;

Change the definition of an enclosure to match SES;

3.1.57 enclosure: [The box, rack or set of boxes providing the powering, cooling, mechanical protection, EMI protection and external electronic interfaces for one or more SCSI devices.](#)

4.1.3 Ports (narrow ports and wide ports)

...

- a) transmit the same [device type, protocol bits \(e.g. SMP TARGET PORT\)](#) and SAS address (see 4.2) during the identification sequence (see 7.9);

...

4.6.2 Expander Ports

An external expander port contains one or more physical phys (see 4.1.2). Each expander phy contains an expander link layer with an XL state machine and an SL_IR state machine. The expander link layers within an expander port request and respond to connection requests independently.

An external expander port shall report the same DEVICE TYPE, protocol bits (e.g. SMP TARGET PORT) and SAS ADDRESS in the IDENTITY address frame (see 7.8.2) for all phys of the port.

An external expander port shall report the same SAS ADDRESS and ROUTING ATTRIBUTE in the SMP DISCOVER (see 10.4.3.5) response for all phys of the port.

An external expander port with a ROUTING ATTRIBUTE set to Table routing attribute shall have the same number of route table entries for all phys of the port.

...

5.2.3.x SAS external receptacle connector restrictions

The pins of an external receptacle connector may be attached to one or more SAS devices (see 4.1.4).

The pins of an external receptacle connector may be attached to only one expander device (see 4.1.5), with the phys attached to the pins representing a single expander port (see 4.6.2).

The second issue is a usability issue that occurs because it is difficult to describe how external connectors may be legally connected.

Using Figure 1 to illustrate the problem. During the plugfest there was no standardized way to reference Connector A and Connector B of each Enclosure. There was also no set of guidelines that described connectivity capabilities of an enclosure.

The remainder of this proposal recommends that a naming convention be provided for external connectors (including icons) that provide guidelines for connectivity.

To resolve this issue, HP would propose the following text and graphics be incorporated in SAS 1.1 Annex L;

The SAS icons are shown in figures L1 to L3. One or more of these icons should be located near the external receptacle connector for SAS devices, expander devices or enclosures compliant with this standard.

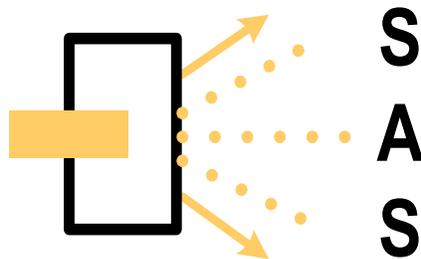


Figure L. 1, SAS Icon for External Receptacle Connections to End Devices (e.g. HBA's or Enclosures without Expander ports)

Figure L2 shows the SAS icon for an external receptacle connection for SAS devices attached to expander ports with the table routing attribute. An enclosure using the external receptacle connector to attach to an expander port with table routing attribute should be referred to as the ENCLOSURE OUT PORT.

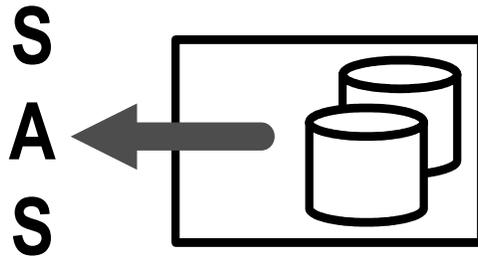


Figure L. 2, SAS Icon for External Receptacle Connections to Expander Ports with Table routing attribute

Editor’s Note: the import of the icon into the word document changed the end point of the arrow from square to round. The preference is for a square endpoint.

Figure L3 shows the SAS icon for an external receptacle connection for SAS devices attached to expander ports with the subtractive routing attribute. An enclosure using the external receptacle connector to attach to an expander port with subtractive routing attribute should be referred to as the ENCLOSURE IN PORT.

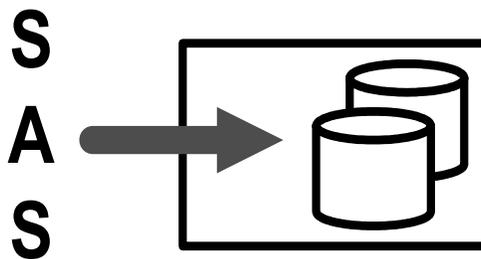


Figure L. 3, SAS Icon for External Receptacle Connections to Expander Ports with Subtractive routing attribute

Editor’s Note: the import of the icon into the word document changed the end point of the arrow from square to round. The preference is for a square endpoint.

Multiple SAS icons should be located on cables that connected SAS devices. Figures L4 to L6 show the placement of combinations of SAS icons on cable external receptacle connections. To facilitate ease of use, cable ends may be identified with different icons.

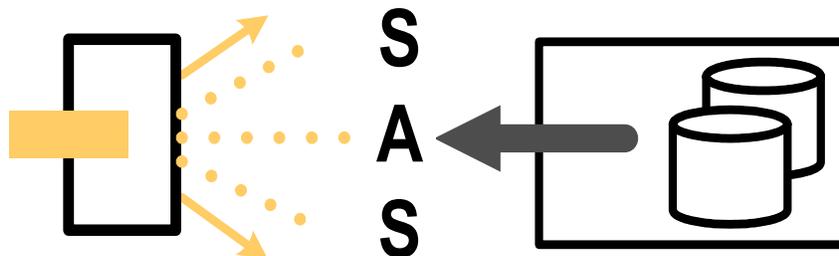


Figure L. 4, SAS Icon for External Receptacle Connections on cables that may be attached to End Devices or Expander Ports with Table routing attribute

Editor's Note: the import of the icon into the word document changed the end point of the arrow from square to round. The preference is for a square endpoint.

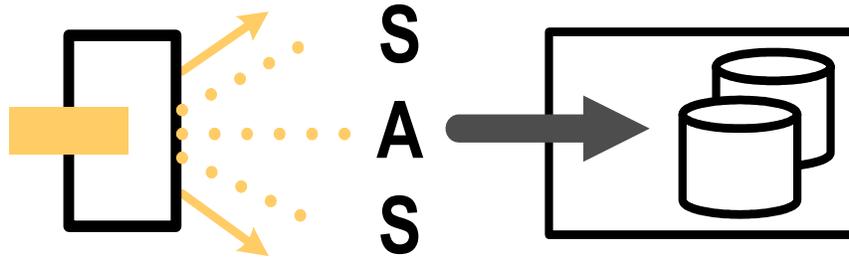


Figure L. 5, SAS Icon for External Receptacle Connections on cables that may be attached to End Devices or Expander Ports with Subtractive routing attribute

Editor's Note: the import of the icon into the word document changed the end point of the arrow from square to round. The preference is for a square endpoint.

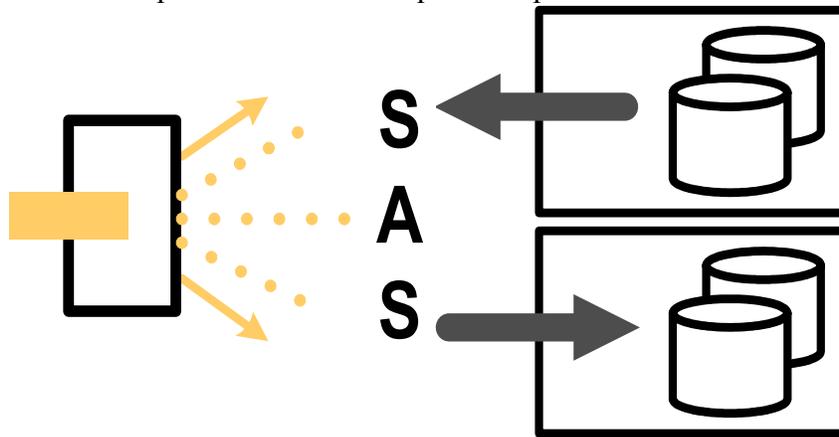


Figure L. 6, SAS Icon for External Receptacle Connections on cables that may be attached to End Devices or Expander Ports with Table or Subtractive routing attribute

Editor's Note: the import of the icon into the word document changed the end point of the arrow from square to round. The preference is for a square endpoint.

Figure L7 shows a cable that connects an end device or expander port with table routing attribute to another end device or expander port with subtractive routing attribute. Each end of the cable is identified with either a label on the external receptacle connector or with a tag affixed near the external receptacle connector.

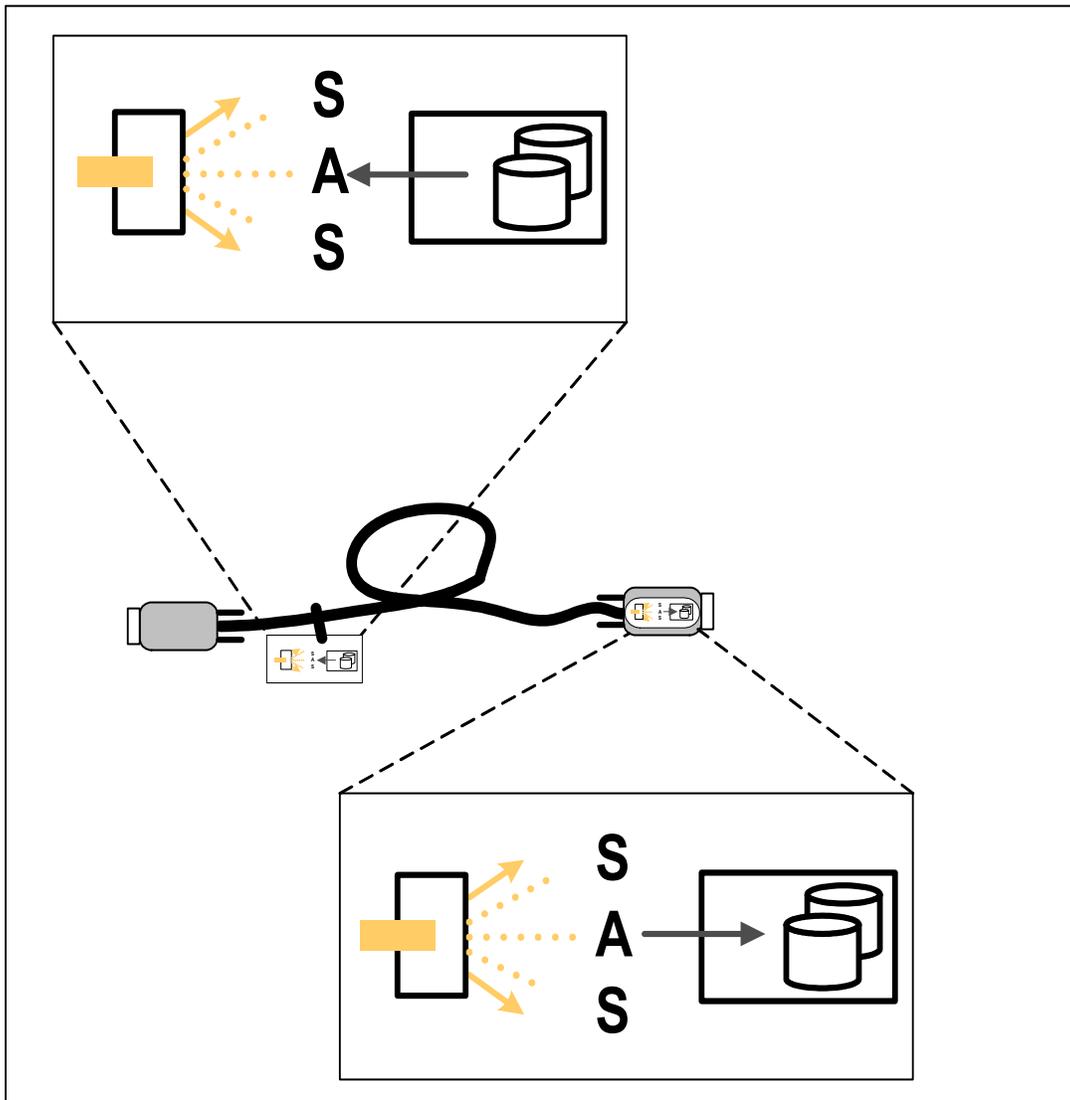


Figure L. 7, Interoperable External Cable using multiple SAS Icons

An example of an HBA and Enclosure being connected with the interoperable external cable is shown in figure L8. Figure L8 also demonstrates that the same interoperable external cable may be used to connect enclosures in a cascaded manner.

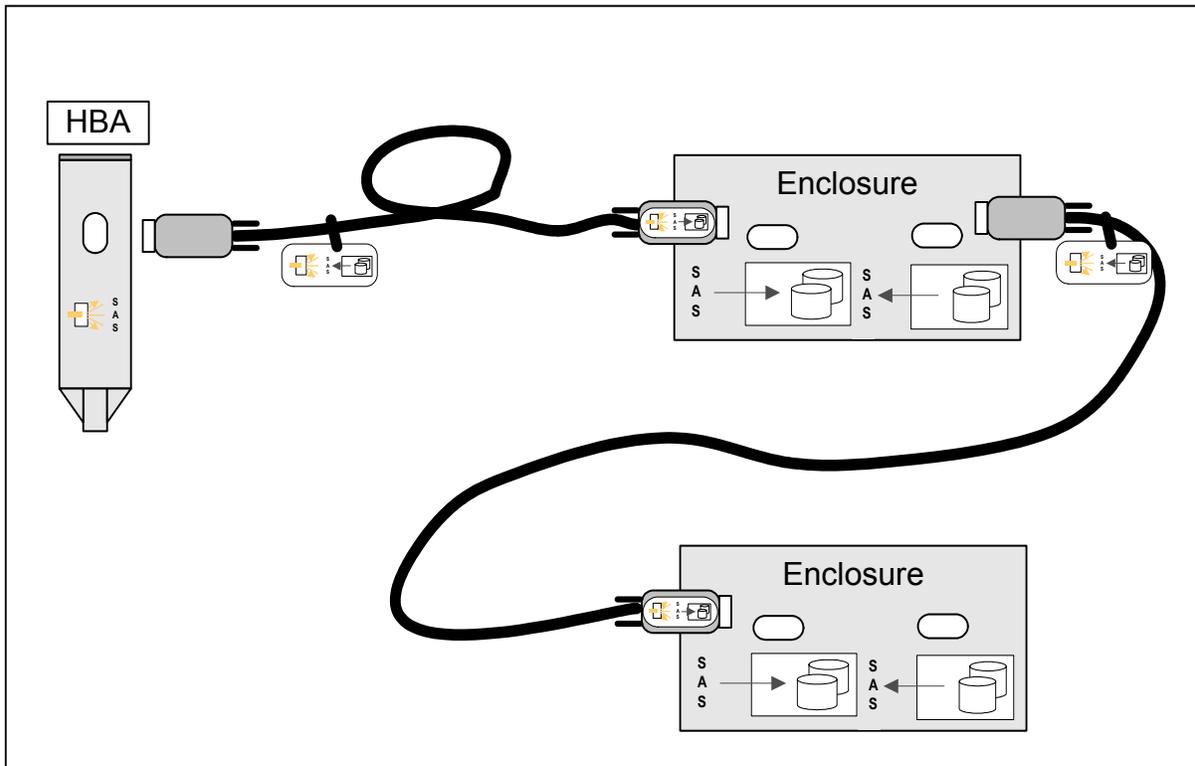


Figure L. 8, HBA to Enclosure connection example using icons

Additionally, the expander device sets contained within an enclosure have a minimal set of connectivity characteristics that should be communicated to the end user to assist in using enclosures.

To resolve this issue, HP would propose a new informative annex be created with the following text (in blue);

Annex x
(informative)

Enclosure Connectivity Capabilities

SAS Enclosures should provide the following information to the user;

- a) The number of SAS devices (e.g. drives) that may be connected (e.g. the number of slots in the enclosure).
- b) The number of SAS device entries provided by the enclosure (e.g. the number of route table entries for the externally connected expander).
- c) The number of SAS device entries consumed by the enclosure (e.g. the number of route table entries consumed by phys that are present, but are not physically routed to any devices and by the number of route table entries consumed by virtual devices).