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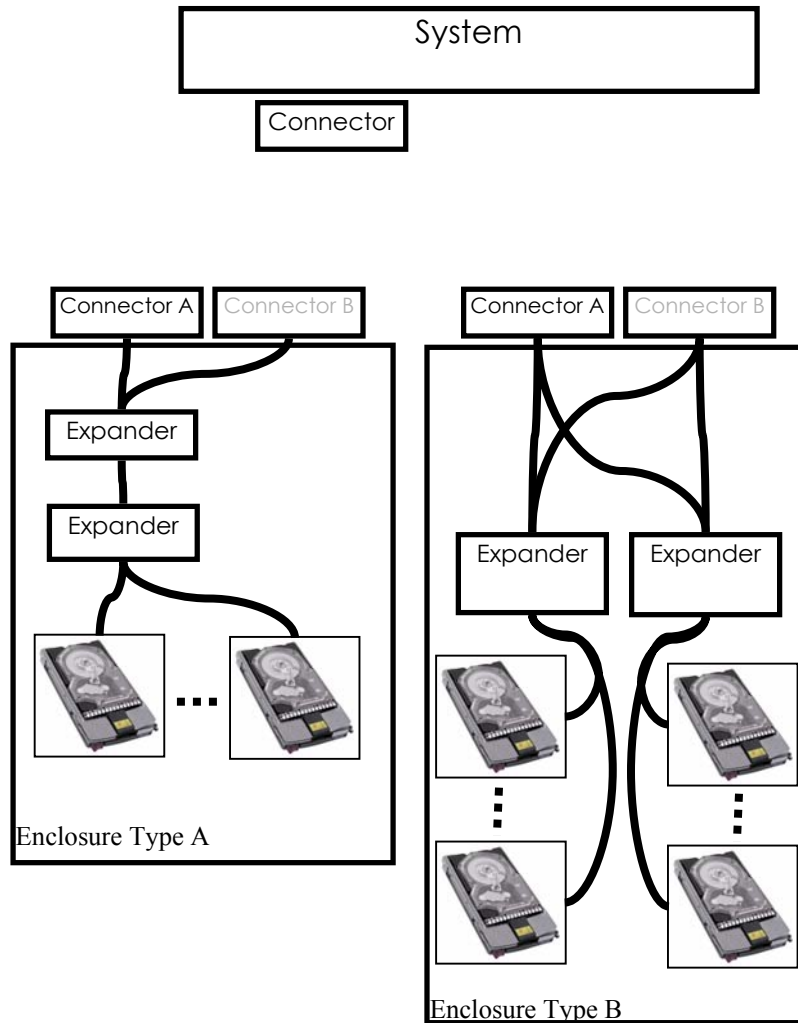
When the System connector was attached to either of the enclosures (from different manufacturers) the devices were properly discovered. Both enclosures were designed to be "daisy chained" to additional enclosures. When enclosures from the same manufacturer were

"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		
Connector A (table routing)	Connector B (subtractive routing)	Connector A (table routing)	Connector B (subtractive routing)	Result
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 clause 5.2.3;

5.2.3.x SAS external receptacle connector restrictions

SAS devices using the external receptacle connector shall be attached to only one device type (i.e. end device type, edge expander device or fanout device).

SAS devices using the external receptacle connector attached to expanders shall be constrained to the following;

a) An external receptacle connector shall be attached to only one expander device type (i.e. edge expander device, or fanout expander device), and
b) An external receptacle connector shall be attached to only one expander device.
   a. The expander phys contained within the external receptacle connector shall define a single port (ie. single SAS address),
   b. The expander phys contained within the external receptacle connector shall have the same routing attribute (i.e. subtractive or table, but not both), and
   c. The expander phys contained within the external receptacle connector that use the table routing attribute shall have the same number of route table entries.

SAS devices using the external receptacle connector may be attached to one or more end devices.

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 a set of 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 figure L1 to L3. One of these icons should be included on all connections to devices compliant with this standard.
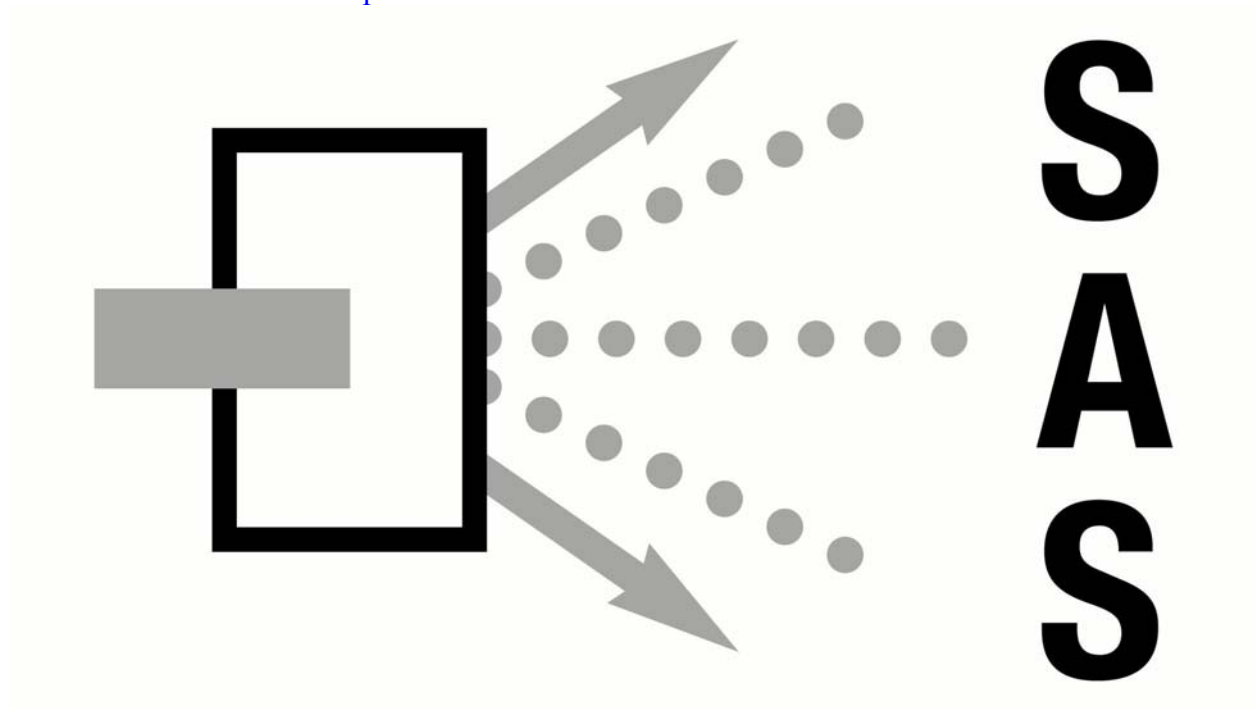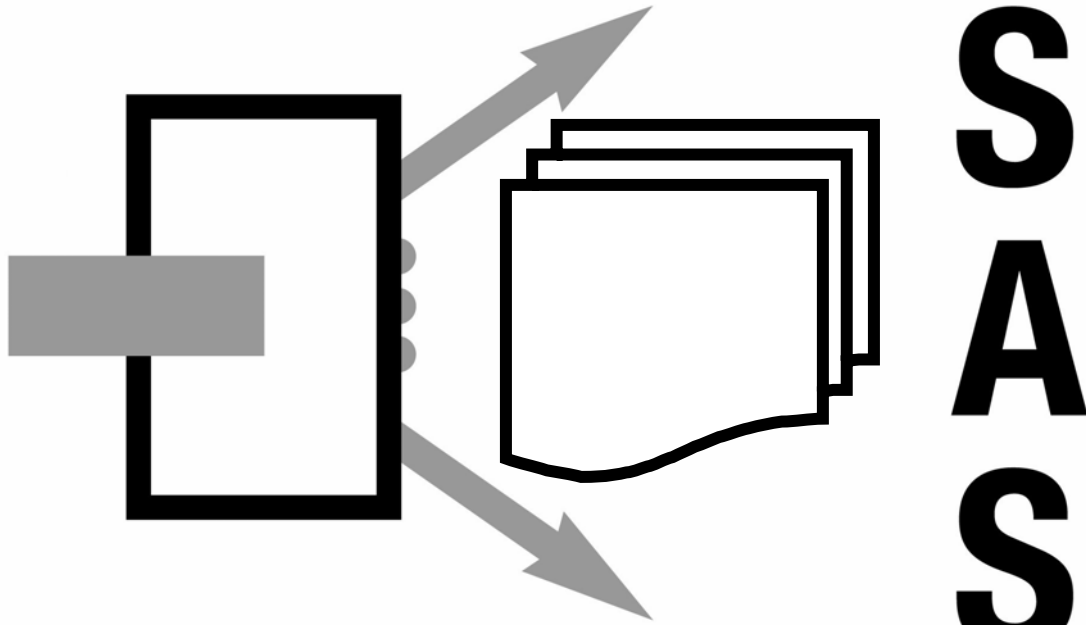

Figure L. 1, SAS Icon for Cables and End Devices

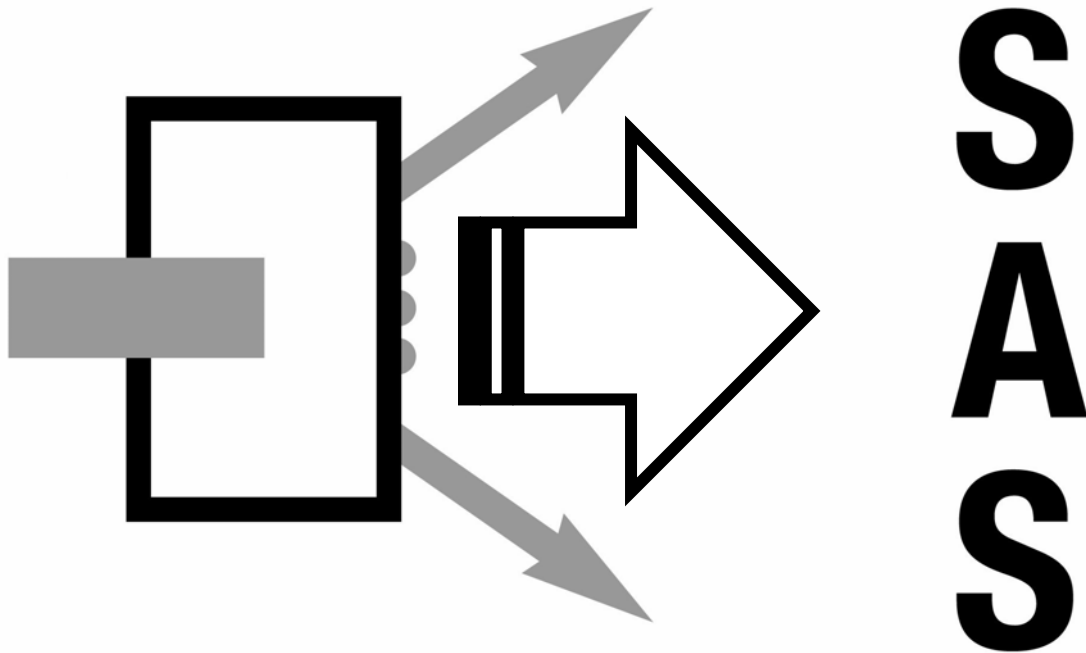**Figure L. 2, SAS Icon for External Connections to Route Table Phys of an Expander**

Figure L. 3, SAS Icon for External Connections to Subtractive Phys of an Expander

The icons should be used to describe the connectivity options between external connectors (see Table L.1).

Table L. 1, External Connectivity using the SAS Icons

	Icon, Figure L.1	Icon, Figure L.2	Icon, Figure L.3
Icon, Figure L.1	yes	yes	yes
Icon, Figure L.2	yes	no	yes
Icon, Figure L.3	yes	yes	yes[1]

Note 1: This option is allowable, but is not recommended since it limits the cascading capabilities of enclosures.

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 JBOD Enclosures should provide the following information to the user;
   a) The number of SAS devices (drives) that may be connected (i.e. the number of slots in the enclosure).
   b) The number of SAS device entries provided by the enclosure (i.e. the number of route table entries for the externally connected expander).
   c) The number of SAS device entries consumed by the enclosure (i.e. 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).