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

<table>
<thead>
<tr>
<th>Enclosure A</th>
<th>Enclosure B</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

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.

...
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.
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).