To:     T10 Technical Committee
From:   Rob Elliott, HP (elliott@hp.com)
Date:   13 June 2006
Subject: 06-279r0 SAS-2 Allow more than one ZDSDS in a SAS domain

**Revision history**
Revision 0 (13 June 2006) First revision

**Related documents**
sas2r04 - Serial Attached SCSI - 2 (SAS-2) revision 4

**Overview**
SAS-2 currently mandates that there be no more than one zoned portion of the service delivery subsystem (ZPSDS) per SAS domain. However, there is no way to enforce this and no reason to do so - a user can easily attach two zoned JBODs together, and they will communicate fine. Each ZPSDS has its own zone manager. How or whether those zone managers communicate to let devices attached to one ZPSDS talk to devices attached to the other is outside the scope of the standard. The zone group numbers in one ZPSDS has no relationship to the zone group numbers in the other ZPSDS.

Figure 1 shows two ZPSDSes. As long as the ZONE PARTICIPATING bits are set to zero at the boundaries, they can coexist.
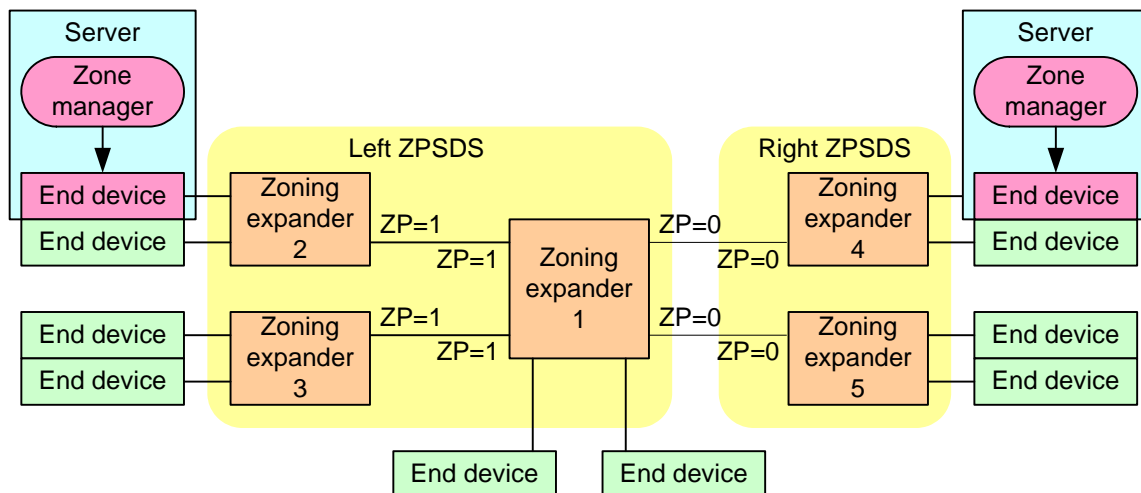


**Figure 1 — Two ZPSDSes introduction**

Future proposals will define ways to extend a ZPSDS (to add non-zoning expanders) and merge ZPSDSes together (i.e., merge another set of zoning expanders in a ZPSDS into one big ZPSDS).

**Suggested changes**

## 4.8 Zoning

### 4.8.1 Zoning overview

SAS zoning is implemented by a set of zoning expander devices that define ~~the~~a zoned portion of a service delivery subsystem (ZPSDS). The zoning expander devices control whether a phy is permitted to participate in a connection to another phy.

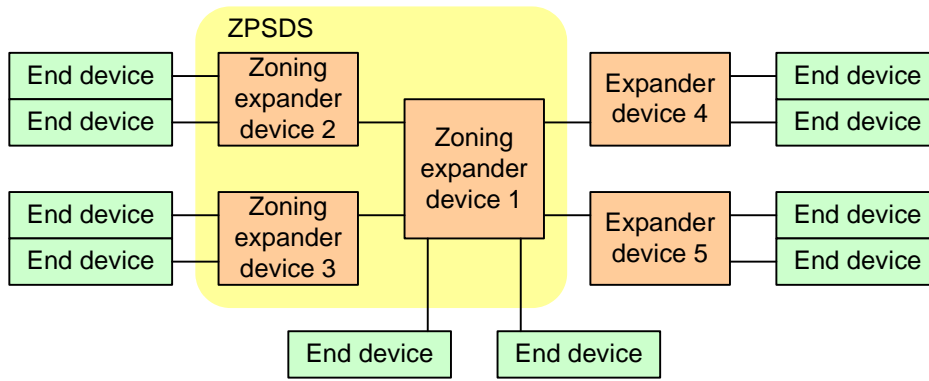Figure 2 shows an example of one ZPSDS in a SAS domain.



**Figure 2 — One ZPSDS example**

A ZPSDS has a zone manager responsible for its configuration. The zone manager may have access to an end device with a SAS port whose zone group has access to zone group 2, or may be attached to one or more zoning expander devices through a mechanism outside the scope of this standard.

Figure 3 shows examples of zone manager locations in a SAS domain.

Zone manager attached to an end device with a SAS port whose zone group has access to zone group 2
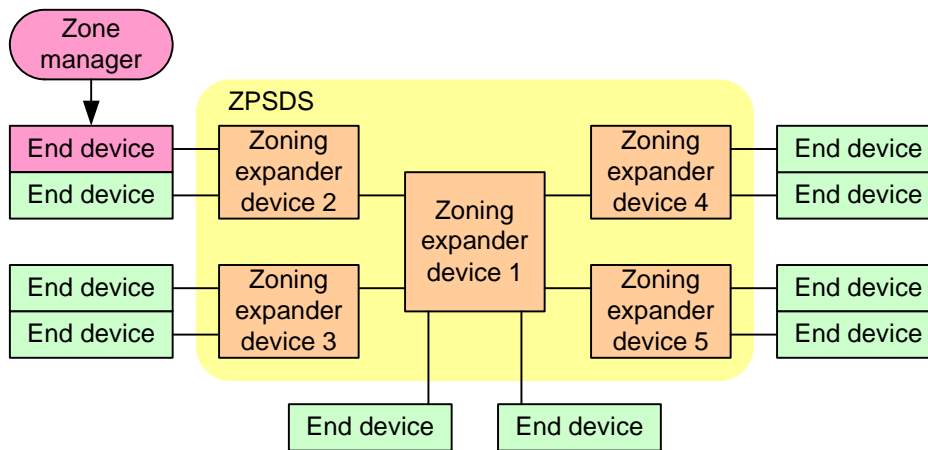


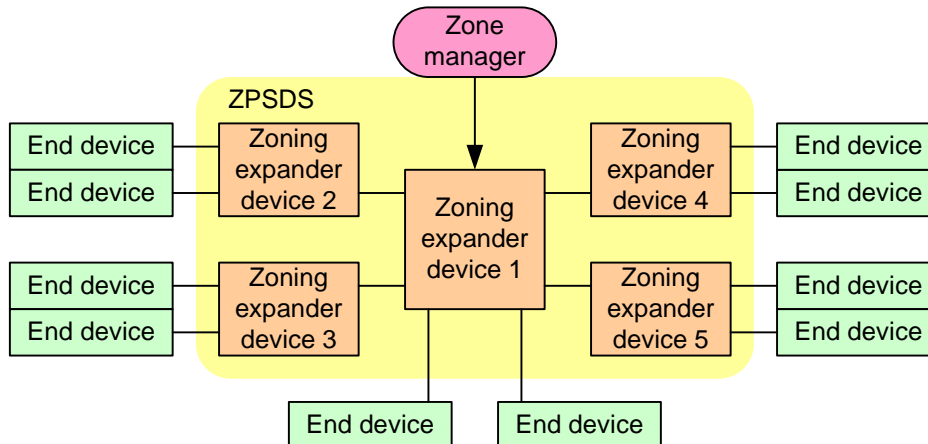Zone manager attached directly to a zoning expander device



**Figure 3 — Zone manager location examples**

There ~~shall be at most one~~may be any number of non-overlapping ZPSDSes in a service delivery subsystem. ~~The~~A ZPSDS may encompass some or all of the service delivery subsystem.

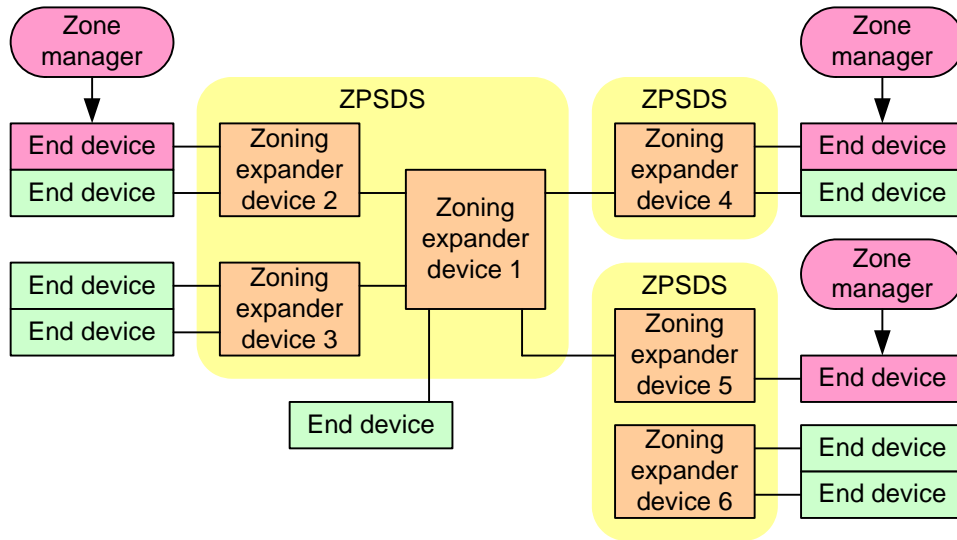Figure 4 shows an example of three ZPSDSes in a SAS domain.



**Figure 4 — Three ZPSDSes example**

~~Every phy in a ZPSDS belongs to a zone group~~The zone manager assigns zone groups (see 4.8.3.2) to all phys that are capable of participating in connections through the ZPSDS. There are 128 zone groups numbered 0 through 127. All phys in a wide port shall ~~belong~~be assigned to the same zone group. Zone group numbers are assigned to zoning expander phys as part of the zone phy information (see 4.8.3.1) and assigned to SAS addresses in the zoning expander route table (see 4.8.3.4). [new paragraph break]

Each zoning expander device contains a zone permission table (see 4.8.3.3) that controls whether a connection is allowed between phys based on their zone groups. ~~the zone group of a source port and the zone group of a target port.~~ [join] As defined in 4.8.3.5, ~~a~~A requested connection shall only be established if the zone permission table indicates that access between the zone group of the source port and the zone group of the target port is allowed.

The zoning expander route table (see 4.8.3.4) is an extended version of the expander route table (see 4.6.7.3) that also includes ~~zone phy information~~the zone group number of each SAS address.

~~The treatment of OPEN address frames received by expander phys on the boundary of the~~a ~~ZPSDS depends on:~~

~~a)   whether the OPEN address frame enters the ZPSDS via a table routing phy; and~~
~~b)   the value of the ZONE ADDRESS RESOLVED bit for the receiving expander phy (see 4.8.3.1).~~

~~If an OPEN address frame is received from a non-zoning expander device via a table routing phy for which the ZONE ADDRESS RESOLVED bit is set to one, then the source zone group is determined based on the source SAS address in the OPEN address frame. In this case, proper management of the zoning expander device extends the zoning capability to beyond the ZPSDS.~~

~~Otherwise, the source zone group is a fixed value that is associated with the receiving expander phy. In this case, non-zoning expander devices are treated in the same manner as end devices and all phys in the non-zoning expander device and all phys attached behind the non-zoning expander device belong to the zone group specified for the receiving expander phy.~~

Editor's Note 1: The above three paragraphs just duplicate material covered in the source zone group determination table 23 in 4.8.3.5.

### 4.8.2 Zoning expander device requirements

In addition to the requirements for expander devices described in 4.6, a zoning expander device shall:

 a)  contain a zoning expander route table (see 4.8.3.4);
 b)  contain a zone permission table that supports 128 zone groups (see 4.8.3.3);
 c)  allow or deny connection requests based on the zone permission table (see 4.8.3.5);
 d)  set the ZONE DEVICE bit to one in its SMP REPORT GENERAL response (see 10.4.3.3);
 e)  be self-configuring;
 f)  contain an SMP initiator port (see 4.6.1); and
 g)  support all zoning-related SMP functions.

### 4.8.3 Zone operation

### 4.8.3.1 Zone phy information

Each phy of a zoning expander device shall support the following zone phy information fields:

 a)  ZONE PARTICIPATING bit;
 b)  ZONE ADDRESS RESOLVED bit;
 c)  ZONE GROUP PERSISTENT bit; and
 d)  ZONE GROUP field.

The ZONE PARTICIPATING bit indicates a boundary of the ZPSDS. The ZONE PARTICIPATING bit shall be set to zero when the phy is attached to an end device or an expander device ~~that does not support zoning~~outside the ZPSDS. The ZONE PARTICIPATING bit shall be set to one when the phy is attached to a zoning expander device inside the ZPSDS.

The ZONE ADDRESS RESOLVED bit ~~specifies~~indicates the method used to determine the source zone group for a connection request received by a phy at the boundary of the ZPSDS as specified in table 25 (see 4.8.3.5).

The ZONE ADDRESS RESOLVED bit may be set to one when:

 a)  the phy is contained within a zoning expander device; and
 b)  the ZONE PARTICIPATING bit for the phy is set to zero.

The ZONE ADDRESS RESOLVED bit shall be set to zero when:

 a)  the phy is contained within a non-zoning expander device; or
 b)  the phy is contained within a zoning expander device and the ZONE PARTICIPATING bit for the phy is set to one.

The ZONE GROUP field has a value in the range of 0 to 127 that indicates the zone group to which the phy belongs. If the ZONE PARTICIPATING bit of the phy is set to one, the ZONE GROUP field shall be set to 1. The zone group of the SMP initiator port and SMP target port in a zoning expander device shall be 1. 4.8.3.2 defines more about zone groups.

The ZONE GROUP PERSISTENT bit ~~specifies~~indicates the method of determining the zone group value of the phy after a link reset sequence (see 4.8.4). If the ZONE PARTICIPATING bit is set to one, the ZONE GROUP PERSISTENT bit shall be set to one.

All phys in an expander port shall have the same zone phy information (see 4.8.3.1). The default (e.g., power on) values for the zone phy information fields are vendor-specific.

**4.8.3.2 Zone groups types**

Zone groups function in different ways based on zone group number as shown in table 23. A zone group with configurable zone permission table entries is able to be changed with the SMP CONFIGURE ZONE PERMISSION function.

**Table 23 — Zone groups types**

| Zone group | Configurable zone permission table entries | Description |
|---|---|---|
| 0 | No | Phys in zone group 0 have access to no other phys except phys in zone group 1. |
| 1 | No | Phys in zone group 1 have access to other phys in all zone groups. |
| 2 | Yes | Phys in zone group 2 have access to other phys based on the zone permission table.<br><br>Phys in zone groups with access to zone group 2 are allowed to perform SMP zoning configuration functions.<br><br>Phys in zone groups without access to zone group 2 are prohibited from performing SMP zoning configuration functions. |
| 3 | Yes | Phys in zone group 3 have access to other phys based on the zone permission table.<br><br>Phys in zone groups with access to zone group 3 are allowed to perform certain SMP zoning related functions (i.e., ZONED BROADCAST).<br><br>Phys in zone groups without access to zone group 3 are prohibited from performing certain SMP zoning related functions (i.e., ZONED BROADCAST). |
| 4 to 7 | Reserved | |
| 8 to 127 | Yes | Phys in zone groups 8 through 127 have access to other phys based on the zone permission table. |

Use of the SMP CONFIGURE PHY ZONE function and SMP CONFIGURE ZONE PERMISSION function shall be restricted based on the zone group 2 permission bits and the source zone group of the SMP initiator port requesting the function (see 4.8.3.5). If the SMP request is CONFIGURE PHY ZONE or CONFIGURE ZONE PERMISSION:

   a)  if the ZP[s, 2] bit is set to one, the management device server shall process the function request; and
   b)  if the ZP[s, 2] bit is set to zero, the management device server shall not process the function request and shall return a function result of SMP ZONE VIOLATION in the response frame (see 10.4.3.2).

Use of the SMP ZONED BROADCAST function shall be restricted based on the zone group 3 permission bits and the source zone group of the SMP initiator port requesting the function (see 4.8.3.5). If the SMP request is ZONED BROADCAST:

   a)  if the ZP[s, 3] bit is set one, the management device server shall process the function request; and
   b)  if the ZP[s, 3] bit is set to zero, the management device server shall not process the function request and shall return a function result of SMP ZONE VIOLATION in the response frame (see 10.4.3.2).

### 4.8.3.3 Zone permission table

The zone permission table specifies access permission between zone groups. If a bit in the zone permission table is set to one then connection requests shall be permitted between phys in the zone groups. If a bit in the zone permission table is set to zero then connection requests between phys in the zone groups shall be rejected with OPEN_REJECT (ZONE VIOLATION) as described in 4.8.3.5.

The zone permission table structure is shown in table 24.

**Table 24 — Zone permission table**

| Destination zone group d | Source zone group s | | | | |
|---|---|---|---|---|---|
| | **0** | **1** | **2 to 3** | **4 to 7** | **8 to 127** |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 to 3 | 0 | 1 | ZP[s = 2 to 3, d = 2 to 3] | Reserved | ZP[s = 8 to 127, d = 2 to 3] |
| 4 to 7 | 0 | 1 | Reserved | Reserved | Reserved |
| 8 to 127 | 0 | 1 | ZP[s = 2 to 3, d = 8 to 127] | Reserved | ZP[s = 8 to 127, d = 8 to 127] |
| Note: Shading identifies configurable zone groups. | | | | | |

A ZP[s, d] bit set to one specifies that zone group s has permission to access zone group d. A ZP[s, d] bit set to zero specifies that zone group s does not have permission to access zone group d.

If ZP[s, d] is set to a value, ZP[d,s] shall be set to the same value.

Zone group 0 shall not have access to any other group except zone group 1 (e.g., bits ZP[0, 0] and bits ZP[2 to 127, 0] are set to zero).

Zone group 1 shall have access to all other zone groups (e.g., bits ZP[0 to 127, 1] are set to one).

Zone groups 4 through 7 are reserved zone groups. All reserved ZP bits shall be set to zero (e.g., bits ZP[4 to 7, 4 to 127] are set to zero).

If an expander phy has the ZONE ADDRESS RESOLVED METHOD bit set to one, then the zone group of that phy shall be configured to have permission to access all the zone groups to which the SAS addresses in the zoning expander route table for that expander phy have access.

### 4.8.3.4 Zoning expander route table

The zoning expander route table in a zoning expander device shall contain zone phy information in addition to the expander phy information.

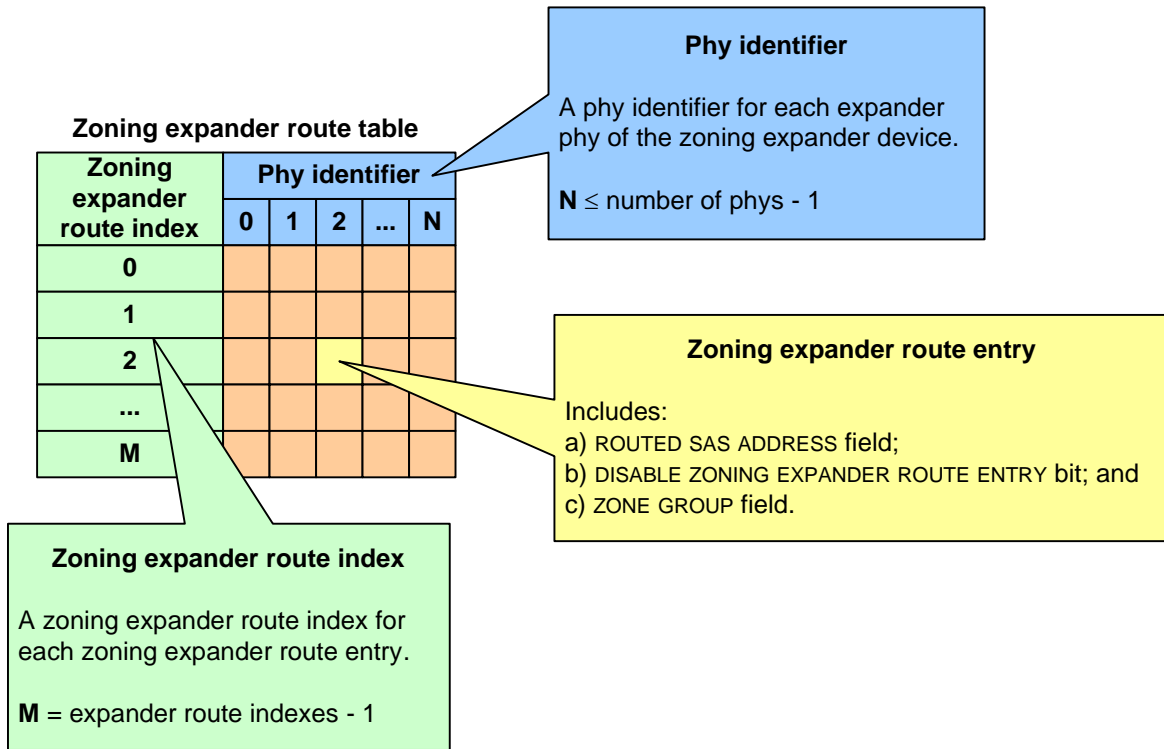Figure 5 shows a representation of a zoning expander route table.

**Phy identifier**

A phy identifier for each expander phy of the zoning expander device.

$N \leq$ number of phys - 1

**Zoning expander route table**

| Zoning expander route index | Phy identifier | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | ... | N |
| 0 | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| ... | | | | | |
| M | | | | | |

**Zoning expander route entry**

Includes:
a) ROUTED SAS ADDRESS field;
b) DISABLE ZONING EXPANDER ROUTE ENTRY bit; and
c) ZONE GROUP field.

**Zoning expander route index**

A zoning expander route index for each zoning expander route entry.

$M$ = expander route indexes - 1

**Figure 5 — Zoning expander route table example**

Some SMP functions may combine information from the zoning expander route table and information from other sources in a single report or configure function.

### 4.8.3.5 Source zone group and destination zone group determination

When a zoning expander device receives an OPEN address frame (see 7.8.3):

  a)  the zone group of the source port (i.e., s) is identified as defined in table 25; and
  b)  the zone group of the destination port (i.e., d) is identified as defined in table 26.

If the ZP[s, d] bit is set to one then access between the phys shall be permitted and the zoning expander device shall perform the ECM arbitration procedure. If the ZP[s, d] bit is set to zero then access between the phys is not permitted and the zoning expander device shall transmit OPEN_REJECT (ZONE VIOLATION) in response to the connection request.

Zoning expander devices shall follow the rules in table 25 to determine the zone group of the source port.

**Table 25 — Source zone group determination**

| Attribute of the expander phy that received the OPEN address frame | | | Source zone group |
|---|---|---|---|
| ZONE ADDRESS RESOLVED bit | Routing method | ZONE PARTICIPATING bit | |
| Zero | Any | Zero | Zone group of the receiving expander phy |
| | | One | Source zone group specified by the SOURCE ZONE GROUP field in the received OPEN address frame |
| One | Direct | Zero | Zone group of the receiving expander phy |
| | | One | Not applicable |
| | Subtractive | Zero | Zone group of the receiving expander phy |
| | | One | Not applicable |
| | Table | Zero | Zone group stored in the zoning expander route table for the source SAS address. If the source SAS address is not found in the zoning expander route table then the zone group of the receiving expander phy. |
| | | One | Not applicable |

Zoning expander devices shall follow the rules in table 26 to determine the zone group of the destination port.

**Table 26 — Destination zone group determination**

| Routing method of the destination expander phy | Destination zone group |
|---|---|
| Direct | Zone group of the destination expander phy |
| Subtractive | Zone group of the destination expander phy (i.e., the subtractive expander phy) |
| Table | Zone group stored in the zoning expander route table for the destination SAS address |

Editor's Note 3: the following figures were pulled out of 4.8.1.

Figure 6 shows an example of a ZPSDS in which the ZONE ADDRESS RESOLVED bit of the expander port of zoning expander device C that is attached to non-zoning expander device D is set to zero.

Zone groups and attributes
 P = ZONE PARTICIPATING bit set to one
 8 = zone group 8
 9 = zone group 9
 10 = zone group 10
 15 = zone group 15
 16 = zone group 16
 17 = zone group 17

ZPSDS

Zoning expander device A
P   8 10   P

End device

Zoning expander device B
8   P
9
9   8

End device

End device

End device

End device

Zoning expander device C
P
16
15  16  17

End device

End device

End device

End device

End device

Non-zoning expander device D

End device

End device

End device

End device

Zone groups of these end devices are the same as that of the non-zoning expander device

Zone permission table
 Zone group 1 has access to all zone groups.
 Zone group 15 has access to zone group 9.
 Zone group 16 has access to zone group 10.
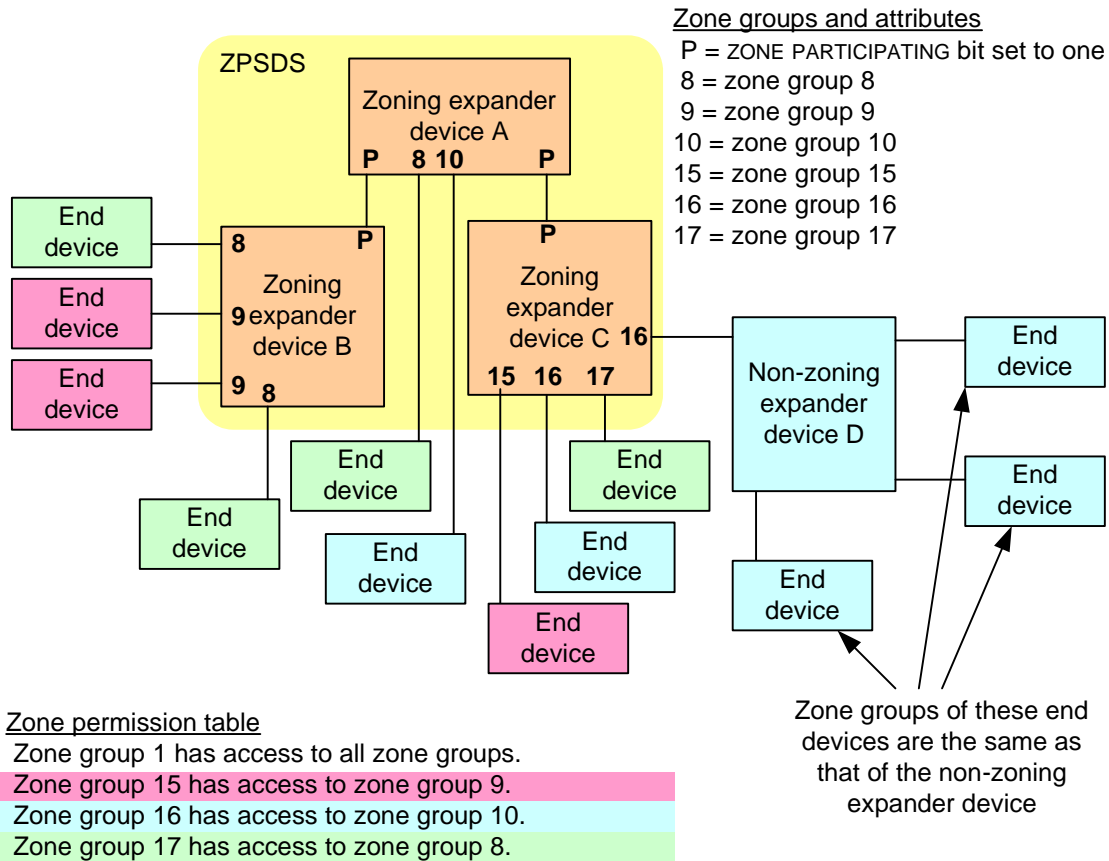 Zone group 17 has access to zone group 8.

**Figure 6 — Example of a ZPSDS with the ZONE ADDRESS RESOLVED bit set to zero**

Figure 7 shows an example of a ZPSDS in which the ZONE ADDRESS RESOLVED bit of the expander port of zoning expander device C that is attached to non-zoning expander device D is set to one.
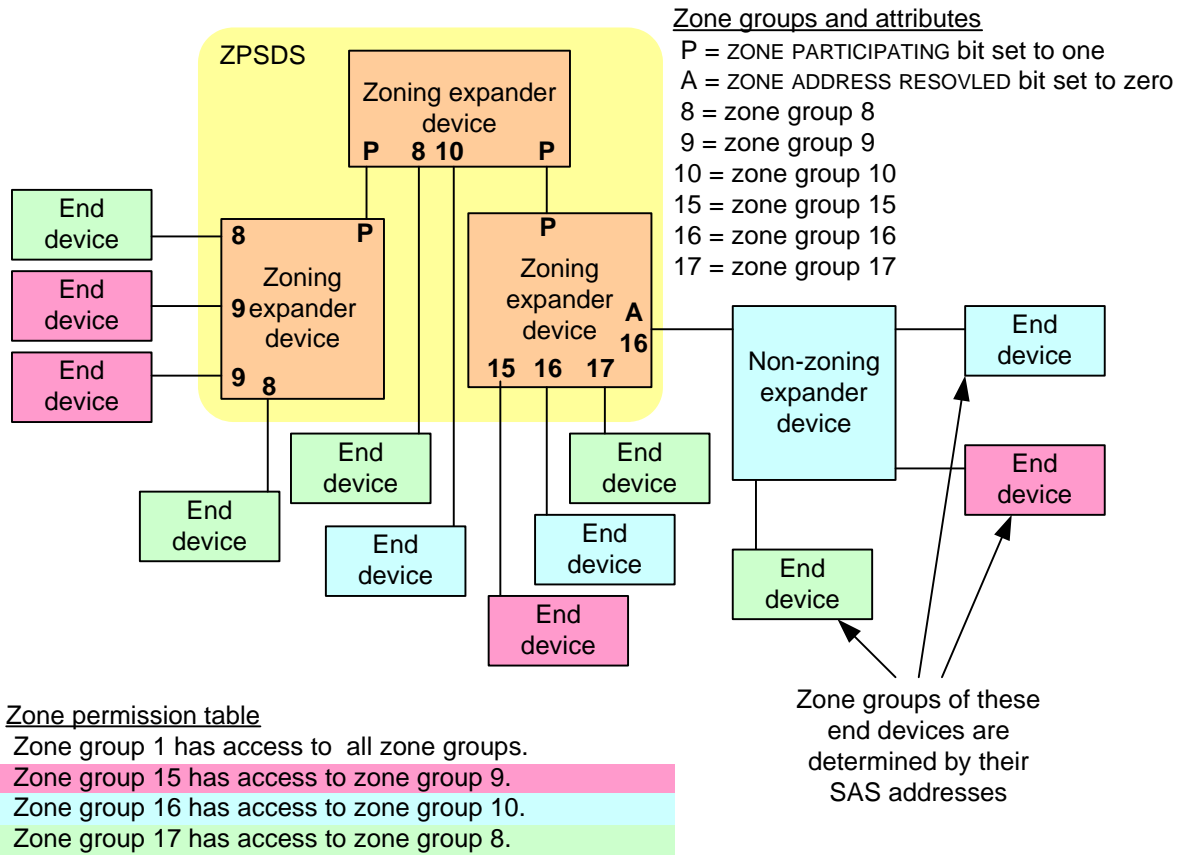
Zone groups and attributes
 P = ZONE PARTICIPATING bit set to one
 A = ZONE ADDRESS RESOVLED bit set to zero
 8 = zone group 8
 9 = zone group 9
 10 = zone group 10
 15 = zone group 15
 16 = zone group 16
 17 = zone group 17

ZPSDS

Zoning expander device
P   8 10   P

End device

8       P
Zoning expander device
9
9   8

End device

End device

P
Zoning expander device   A
                          16
15   16   17

Non-zoning expander device

End device

End device

End device

End device

End device

End device

End device

End device

End device

End device

Zone groups of these end devices are determined by their SAS addresses

Zone permission table
 Zone group 1 has access to  all zone groups.
 Zone group 15 has access to zone group 9.
 Zone group 16 has access to zone group 10.
 Zone group 17 has access to zone group 8.

**Figure 7 — Example of a ZPSDS with the ZONE ADDRESS RESOLVED bit set to one**

### 4.8.4 Zone groups and link reset sequences

If the ZONE GROUP PERSISTENT bit is set to one, then a link reset sequence (see 4.4) shall not cause the zone group value of an expander phy to change. If the ZONE GROUP PERSISTENT bit is set to zero, then table 27 specifies events based on the initial condition of the expander phy that shall cause the zoning expander device to change the ZONE GROUP field of the expander phy to its default value (e.g., zero).

**Table 27 — Events that cause the ZONE GROUP field to be set to its default value when the ZONE GROUP PERSISTENT bit set to zero**

| Initial condition | Event after the initial condition is established |
|---|---|
| Completed link reset sequence with a SAS device attached | A subsequent link reset sequence completes and:<br>a)  the SAS address received in the IDENTIFY address frame (see 7.8.2) during the identification sequence is different from the SAS address prior to the completion of the link reset sequence; or<br>b)  a SATA device is attached. |
| Completed link reset sequence with a SATA device attached | Either:<br>a)  A subsequent link reset sequence completes and:<br>  A)  a hot-plug timeout (see 6.7.5) occurred between the time of the initial condition and the time the link reset sequence completed;<br>  B)  the zoning expander device has detected the possibility that a new SATA device has been inserted. The method of detection is outside the scope of this standard (e.g., an enclosure services process reports a change in the ELEMENT STATUS CODE field in the Device or Array Device element (see SES-2), or a change in the WORLD WIDE NAME field in the attached SATA device's IDENTIFY DEVICE or IDENTIFY PACKET DEVICE data (see ATA8-ACS)); or<br>  C)  a SAS device is attached;<br><br>or<br><br>b)  The expander phy is disabled with the SMP PHY CONTROL function (see 10.4.3.14) DISABLE phy operation. |

### 4.8.5 Broadcast processing in a zoning expander device

The BPP determines the source zone group(s) of the Broadcast as follows:

a)  if the BPP receives a Broadcast Event Notify message from an expander phy (i.e., a zoning expander phy received a BROADCAST), the Broadcast has a single source zone group set to the zone group of that expander phy; and

b)  if the BPP receives a message from the management device server indicating that it received an SMP ZONED BROADCAST request from an SMP initiator port that has access to zone group 3, the Broadcast has each of the source zone groups specified in the SMP ZONED BROADCAST request.

The BPP forwards the Broadcast to each expander port other than the one on which the Broadcast was received (i.e., the expander port that received the BROADCAST or SMP ZONED BROADCAST request) if any of the source zone groups have access to the zone group of the expander port.

To foward a Broadcast to an expander port:

a)  if the expander port's ZONE PARTICIPATING bit is set to one, the BPP shall request that the SMP initiator port establish a connection on at least one phy in the expander port to the SMP target port of the attached expander device and transmit an SMP ZONED BROADCAST request specifying the source zone group(s); and

b)  if the expander port's ZONE PARTICIPATING bit is set to zero, the BPP shall send a Transmit Broadcast message to at least one phy in the expander port, causing it to transmit a BROADCAST.