Date: Feb 05,1994   X3T10/94-031 rev 1

To: X3T9.2 Committee (SCSI)

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Subject: SCSI-3 Logical Unit Addressing

1.0 Overview

SCSI-2 only allows eight Logical Units to be addressed under
a single Target. SCSI-3 parallel has expanded this to 64
Logical Units by using three additional bits in the Identify
message. However, 64 Logical Units is not enough to handle
SCSI Disk Arrays.

SAM has defined a 64 bit address space for Logical Units and
this address space is being used by the SCSI-3 serial
interfaces. SCSI-3 parallel needs a way use the 64 bit
address space. This proposal defines a method for SCSI-3
parallel to take advantage of the expanded address space.
The method uses a five bit address space as a pointer into a
translation table that contains 64 bit addresses.

This proposal also covers a proposed method of addressing the
multiple layers which are created with SDA devices. This
method uses the 64 bit address space to, not only address the
device, but to also indicate the location of the device
within the tree structure of a SDA device.

2.0 Base Device Address

All targets shall accept LUN 0 as an address. For targets
that have more than one logical unit, logical unit
zero shall be the logical unit that an application client
addresses to determine information about the target and the
logical units attached to it.

3.0 Translation Table Addressing

This method uses a translation table to address devices. The
translation table is defined using Mode Sense/Select commands.
When translation addressing is active logical unit addresses
1-31 of the Identify message shall each point to a specific
eight byte location within a translation table. The eight
byte location shall then be used by the target to determine to
which bus/target/LUN to send the command.

This mode page shall only be used for SDA type devices.

The definition of this mode page follows:

.pa
Table x: LUN Mapping Page

```
--------------------------------------------------------------------------------
 Bit| 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
 Byte|    |     |     |     |     |     |     |     |
--------------------------------------------------------------------------------
 0  |  PS  |Reserved|        Page Code (xxh)              |
----+----------------------------------------------------------------------|
 1  |                      Page Length (FAh)              |
----+----------------------------------------------------------------------|
 2  |                      Reserved                       |
----+----------------------------------------------------------------------|
 3  |                      Reserved              |Active |
----+----------------------------------------------------------------------|
 4  | (MSB)                                               |
----+---              LUN 1 Mapping                    ---|
 11 |                                           (LSB) |
--------------------------------------------------------------------------------
 12 | (MSB)                                               |
----+---              LUN 2 Mapping                    ---|
 19 |                                           (LSB) |
--------------------------------------------------------------------------------
 244| (MSB)                                               |
----+---              LUN 31 Mapping                   ---|
 251|                                           (LSB) |
--------------------------------------------------------------------------------
```

When translation addressing is active, the logical unit
addresses 1-31 of an Identify message shall reference a
specific eight byte location within a translation table. The
eight byte location shall then be used by the target to
determine to which bus/target/LUN to send the command.

| The change of an address that is part of a current or pending
| task shall be delayed until the task is complete.

An Active bit of zero indicates the translation table shall
not be used. An Active bit one indicate that the translation
table shall be used to determine to which bus/target/LUN to
send the command.

The LUN xx Address Translation fields contain the eight byte
bus/target/LUN of the device to be addressed. The layout of
this field is defined in section 5.0. A value of all zeros in
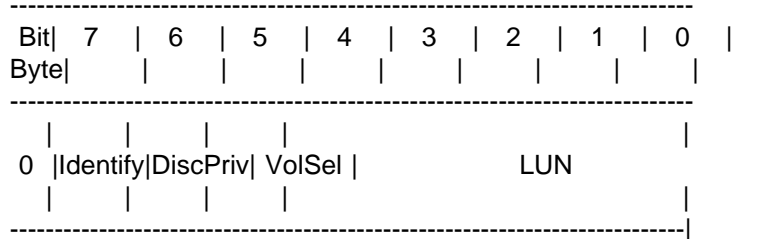this field shall indicate an undefined LUN.

Any attempt to address an undefined LUN xx Mapping field shall
be terminated with a CHECK CONDITION status. In response to a
REQUEST SENSE command the target shall return sense data. The
sense key shall be set to ILLEGAL REQUEST and the additional
sense code shall be set to LOGICAL UNIT NOT SUPPORTED.
.pa
4.0 SDA Identify Message

For SCSI devices that are identified as SDAs bit 5 of the
Identify message indicates the addressed SDA shall use the
LUN as a V-LUI, P-LUI, or as a pointer into the LUN mapping
mode page.

IDENTIFY message format

```
-------------------------------------------------------------------------
 Bit|  7  |  6  |  5  |  4  |  3  |  2  |  1  |  0  |
 Byte|     |     |     |     |     |     |     |     |
-------------------------------------------------------------------------
    |     |     |     |     |                          |
 0  |Identify|DiscPriv| VolSel |           LUN               |
    |     |     |     |     |                          |
-------------------------------------------------------------------------|
```

The IDENTIFY message is sent by either the initiator or the
target to establish an I_T_L nexus. For dual port
implementations: if the target disconnects from the bus
during an I/O process, it shall reconnect through the same
port when the I/O process is continued.

The identify bit shall be set to one to specify that this is
an IDENTIFY message.

A disconnect privilege (DiscPriv) bit of one specifies that
the initiator has granted the target the privilege of
disconnecting. A DiscPriv bit of zero specifies that the
target shall not disconnect. This bit is not defined and
shall be set to zero when an IDENTIFY message is sent by a
target.

The VolSel bit shall only be used for SDA peripheral device
types. Other device types shall use this bit as an extension
of the LUN field.

A VolSel bit of zero specifies that a SDA peripheral device
type shall use the LUN as either a reference into the LUN
mapping mode page (if the active bit within the LUN mapping
mode page is set to one) or as the address of a P-LUI within a
SDA peripheral device type (if the active bit within the LUN
mapping mode page is set to zero or there is no LUN mapping
mode page defined).

Note: All P-LUI addresses default to vendor specific values.
V-LUI addresses may default to vendor specific values or
may be defined by an Application Client during configuration.

A VolSel bit of one specifies that a SDA peripheral device
type shall use the LUN as the address of a V-LUI controlled by
the SDA.

The logical unit number (LUN) field specifies a logical unit
number. For the target's response to an incorrect logical

unit selection see the SCSI Architecture Model.

Only one logical unit number shall be identified per I/O
process. The initiator may send one or more IDENTIFY messages
during a connection. A second IDENTIFY message with a
different value in the LUN field shall not be issued before a
BUS FREE phase has occurred; if a target receives a second
IDENTIFY message with a different value in this field, it
shall issue a Bus Free Request (see Unexpected Bus Free
condition, 5.1.3). Thus an initiator may change the DiscPriv
bit, but may not attempt to switch to another I/O process.
(See the DTDC field of the disconnect-reconnect mode page in
the SCSI-3 Command Set for additional controls over
disconnection.)

An implied RESTORE POINTERS message shall be performed by the
initiator prior issuing a message in response of a message in
indication for an IDENTIFY message sent during reconnection.

5.0 8-byte Logical Unit Number structure

The logical unit number (LUN) allows up to four levels of
devices to be addressed under a single target. Each level
shall use bytes 0-1 to define the address and/or location of
the SCSI device to be addressed.

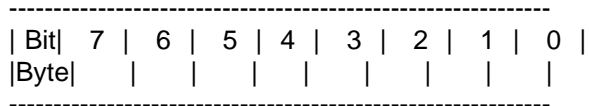This 8-byte LUI structure shall only be valid for SDA type
devices.

If the LUN indicates that the command is to be passed to the
next layer then the SCSI device shall use bytes 0-1 for the
LUN field to determine the LUI to send the command. When the
command is sent to the target the LUN value that was received
shall be adjusted as follows:
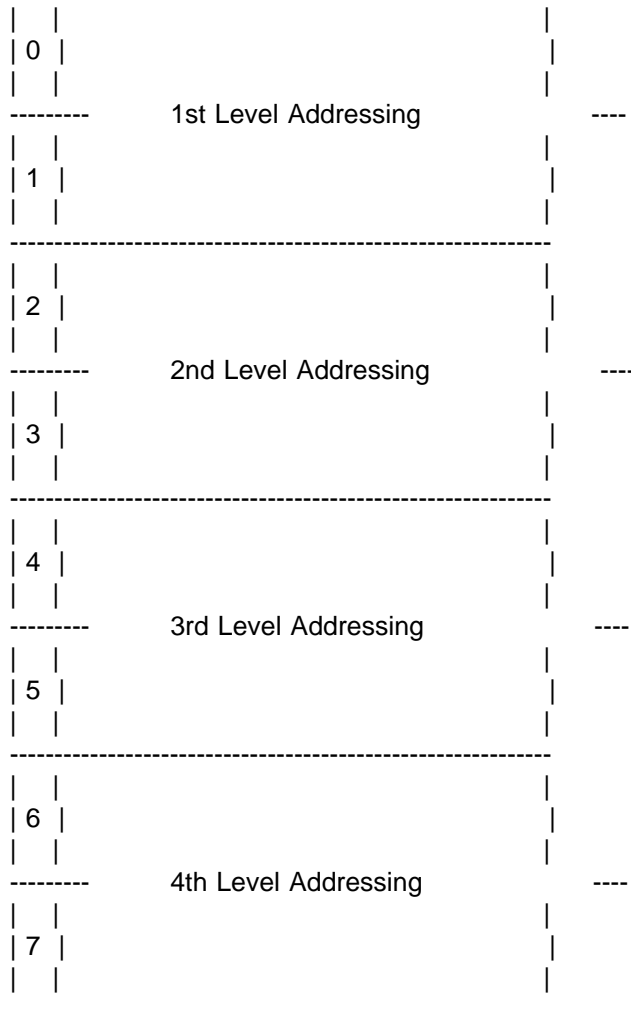
          Byte Position
   Old   New
  0 - 1   Not Used
  2 - 3   Moves to   0 - 1
  4 - 5   Moves to   2 - 3
  6 - 7   Moves to   4 - 5

Bytes six and seven of the new LUN value shall be set to
zero.
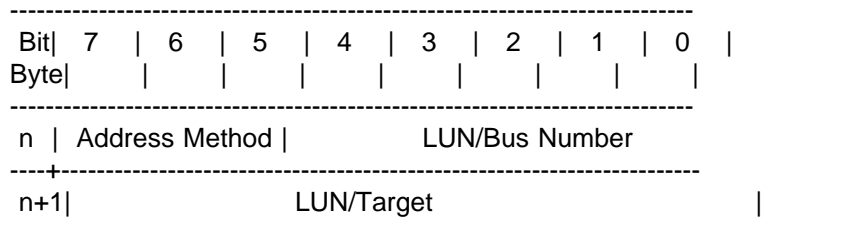
Each SDA shall keep track of the necessary LUI information to
allow reconnection to the correct I/O process during
reselection.
.pa
```
 ---------------------------------------------------------------
| Bit|  7  |  6  |  5  |  4  |  3  |  2  |  1  |  0  |
|Byte|     |     |     |     |     |     |     |     |
 ---------------------------------------------------------------
```

```
|  |                                           |
| 0 |                                          |
|  |                                           |
 ---------        1st Level Addressing         ----
|  |                                           |
| 1 |                                          |
|  |                                           |
 ---------------------------------------------------------
|  |                                           |
| 2 |                                          |
|  |                                           |
 ---------        2nd Level Addressing         ----
|  |                                           |
| 3 |                                          |
|  |                                           |
 ---------------------------------------------------------
|  |                                           |
| 4 |                                          |
|  |                                           |
 ---------        3rd Level Addressing         ----
|  |                                           |
| 5 |                                          |
|  |                                           |
 ---------------------------------------------------------
|  |                                           |
| 6 |                                          |
|  |                                           |
 ---------        4th Level Addressing         ----
|  |                                           |
| 7 |                                          |
|  |                                           |
 ---------------------------------------------------------
```
.pa
The nth level addressing field is defined as follows:

```
------------------------------------------------------------------------
 Bit|  7  |  6  |  5  |  4  |  3  |  2  |  1  |  0  |
 Byte|     |     |     |     |     |     |     |     |
------------------------------------------------------------------------
 n  | Address Method |            LUN/Bus Number            |
----+-------------------------------------------------------------------
 n+1|                     LUN/Target                        |
------------------------------------------------------------------------
```

The value of the address method field determines the contents
of the remaining 14 bits of the nth level addressing field.
The following defines the address methods:

Bit
7 6   Description

0 0   Physical Logical Units
0 1   Volume Logical Units
1 0   Reserved

1 1   Reserved

Physical logical units are either logical units that are
located within the current level or logical units that require
the received command to be sent to another target for
execution. When this address method is indicated bits 5-0 of
byte n shall indicate a bus number.

If the bus number is zero then byte n+1 shall be the LUN
address of a logical unit located within the current level.
If the bus number is greater than zero then byte n+1 shall
indicate a target address. The bus number and target
together indicate which SCSI device the command is to be sent
for further processing.

Volume logical units are logical units that are controlled by
the current level and require one or more accesses to other
targets to execute the command. Volumes shall only be
accepted on SDA device types. See SCSI Disk Array Model for
a complete description of the rules for using volumes. When
this address method is indicated bits 5-0 of byte n and 7-0
of byte n+1 shall be the LUN address. Bit 5 byte n shall be
the MSB and Bit 0 byte n+1 shall be the LSB.

| Note: The value of the Target is defined by the individual
| protocol documents. (e.g. SIP defines Targets to be in the
| range 0-15.)

6.0 Addressing Examples for the 8-byte LUN structure

Several addressing examples follow. The conventions used
within these examples are:

Layer 1   M:P:T or M:L or u
Layer 2   M:P:T or M:L or u
Layer 3   M:P:T or M:L or u
Layer 4   M:P:T or M:L or u

Where:
   M is the Address Method (2 bit field)
   P is the Bus Number (6 bit field)
   T is the Target (8 bit field)
   L is the Logical Unit Number (14 bit field)
   u is means unused and set to zero (16 bit field)

Note that P is a value that starts at one, since the zero
value is reserved for the SDA and devices that have no
external path.

Note that T is a value that starts at zero and is limited to
one less than the number of attachable SCSI devices, since the
path initiator's address is also included in that address
space.

Example 1:

Addressing the first layer SDA (for all control, creation, management functions and for identify)

Layer 1   0:0:0
Layer 2   u
Layer 3   u
Layer 4   u

Addresses will appear on the first level paths as required by the function.

Example 2:

Addressing a fan at address 7 within the first layer SDA (a SCSI device not physically on an identifiable SCSI path, or if you prefer, a LUN of the SDA controller itself.)

Layer 1   0:0:7
Layer 2   u
Layer 3   u
Layer 4   u

No first level path will be used.

Example 3:

Addressing a local P-LUI

The address of the second drive on the third path would be:

Layer 1   0:3:1
Layer 2   0:0:0
Layer 3   u
Layer 4   u

The second level path would use path 3 to access target 1. The LUN value of 0 would be taken from the 0:0:0.

Example 4:

Addressing any V-LUI controlled by the first SDA (including V-LUI's constructed from PS-extents defined by lower SDA's)

Layer 1   1:L
Layer 2   u
Layer 3   u
Layer 4   u

Addresses will appear on the first level paths as required by the function.

Example 5:

Addressing an SDA at the second layer of the hierarchy. Note
that the second layer SDA is also a physical target on the
first layer path. In this example the SDA is on the fourth
path and third target address.

Layer 1   1:4:2
Layer 2   0:0:0
Layer 3   u
Layer 4   u

A LUN address of the following form would be emitted on the
fourth path to target address 2 (following the shift the
address rules) to get at the SDA.

Layer 1   0:0:0
Layer 2   u
Layer 3   u
Layer 4   u

Example 6:

Addressing a P-LUI of the above second level SDA (the second
drive on the third path of that second level SDA).

Layer 1   0:4:2
Layer 2   0:3:1
Layer 3   0:0:0
Layer 4   u

The LUN address emitted on the fourth path to target address 2
(following the shift the address rules). This P-LUI could be
used as a component of a V-LUI defined by the first level SDA
or the second level SDA.

Layer 1   0:3:1
Layer 2   0:0:0
Layer 3   u
Layer 4   u

The LUN address emitted on the third path of the second level
SDA to target address 1 would be 0, taken from the 0:0:0
value.

Example 7:

Addressing any V-LUI of the above second level SDA. Note that
the second level SDA's entry path is being addressed directly.
This V-LUI could be used as a component of a V-LUI defined by
the first layer SDA.

Layer 1   0:4:2
Layer 2   1:L
Layer 3   u
Layer 4   u

Address emitted on the fourth path to target address 2
(following your shift the address rules). This is a standard
V-LUI address.

Layer 1   1:L
Layer 2   u
Layer 3   u
Layer 4   u

Addresses will appear on the second level paths as required by
the function.

Example 8:

Addressing a P-LUI that has real LUN's behind a standard
target. As an example, LUN 4 behind the second target on the
third path of the first level SDA.

Layer 1   0:3:1
Layer 2   0:0:4
Layer 3   u
Layer 4   u

Note that the LUN address emitted on the third first level
path to target 4 is taken from the same place as it normally
would be taken. The value would be 0/0/4 (or 4). This is
analogous to the fan case, above.

Example 9:

Note that the fourth layer devices must be single LUN devices.
As a P-LUI addressing example, if the first layer was B=3,T=7;
the second layer was B=4, T=6; the third layer was B=1, T=5;
and the fourth layer was B=7, T=2 then the address would be:

Layer 1   0:3:7
Layer 2   0:4:6
Layer 3   0:1:5
Layer 4   0:7:2
          0:0:0

the fifth layer must be understood to have only single LUN
devices in it. As we shift down we see:

The LUN issued on the first layer path 3, target 7 would be:

Layer 1   0:4:6
Layer 2   0:1:5
Layer 3   0:7:2
Layer 4   0:0:0

The LUN issued on the second layer path 4, target 6 would be:

Layer 1   0:1:5

Layer 2   0:7:2
Layer 3   0:0:0
Layer 4   u

The LUN issued on the third layer path 1, target 5 would be:

Layer 1   0:7:2
Layer 2   0:0:0
Layer 3   u
Layer 4   u

The LUN issued on the fourth layer path 7, target 2 would
necessarily be:

Layer 1   0:0:0
Layer 2   u
Layer 3   u
Layer 4   u

| 7.0 Addressing Examples for the 6-bit LUN structure
|
| The following examples assume the LUN Mapping Page is not
| active.
|
| Several addressing examples follow. The conventions used
| within these examples are:
|
| Layer 1   V:L
|
| Where:
| V is the Volume Select (1 bit field)
| L is the Logical Unit Number (5 bit field)
|
| Note: Information on logical units at layers below layer 1
| is not available to the application client when the 6-bit LUN
| structure is used. Logical units below layer 1 may only be
| addressed directly using a vendor specific translation of the
| 6-bit LUN.
|
| Example 1:
|
| Addressing the first layer SDA (for all control, creation,
| management functions and for identify)
|
| Layer 1   0:0
|
| Addresses will appear on the first level paths as required by
| the function.
|
| Example 2:
|
| Addressing a fan at address 7 within the SDA.
|
| Layer 1   0:7

| No first level path will be used.
|
| Example 3:
|
| Addressing any P-LUI.
|
| The address of a drive in the SDA:
|
| Layer 1   0:L
|
| Addresses will appear on the first level paths as required by
| the function.
|
| Example 4:
|
| Addressing any V-LUI:
|
| Layer 1   1:L
|
| Addresses will appear on the first level paths as required by
| the function.