# Chapter 15
# -
# Fibre Channel Mass Storage (FCMS)

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# Fibre Channel Basics

Fibre Channel is a communication protocol that has been developed to satisfy the needs of a growing demand for data throughput. The advantages are as follows:

- different channels and protocols over one physical interface
- high bandwidth (200MB/s or higher)
- flexible setup (topology)
- connections across great distances (a couple of kilometers)
- supports different speeds, media and connections

generally spoken fibre channel combines the advantages of channel and networking technology. A channel is a limited, direct, structured and predictable mechanism for data transmission between a few participants. A channel is typically used in situations where a high transfer rate is needed (e.g. connection of peripheral devices like disks, tape drives, printer or workstations). Well known channel protocols are e.g. SCSI or HIPPI.

Networks are non-structured and unpredictable. They are able to adapt automatically to changing environments and allow a higher number of participants. Hence a higher administration effort (mostly in software) is neccessary in order to establish a connection between two points in the network. Thus networks are slower than channels. Well known network protocols are Ethernet, Token Ring or FDDI.

In this chapter we are talking solely about the usage of fibre channel in order to address mass storage devices. This is called FCMS (fibre channel mass storage)

FC is used as the transmission media for SCSI connections. The SCSI protocol is somehow encapsulated.

The essential advantages of FC compared to SCSI are

| | SCSI | FC |
|---|---|---|
| Distance | 25m | 100km |
| Speed | 20MB/s | 200MB/s |
| Number of devices | 15 | 126 ports in AL. Much more with fabric |
| Reliability | | extremely low error rate |
| Robustness | | no HW damages by pulling cables |

**NOTES:**
The maximum supported distance between two FC hubs/switches without using special HW like DWDMs or Power-GBICs is 10km. The maximum distance from a device port (N or NL) to another port (F, FL or NL) is 500m for 1Gbit/s and 300m for 2GBit/s. The cable attenuation needs to be measured in all cases.

| | | |
|---|---|---|
| **FC media** | 9µm single mode fibre | long wave (10km, 1300nm laser) |
| | 50µm multimode fibre | short wave (500m, 780nm laser) |
| | 62,5µm multimode fibre | FDDI (175m) (possibly mass storage) |

The cables should not be bended too strong because they could break. The minimal radius

is 3cm. According to the *can of coke rule* the limitional radius when winding a FC cable is the one of a can of coke.

# Topologies

A physical connection at a port consists of two separate fibers because FC is a serial protocol. The fibers for receive (RX) and transmit (TX) are bundled in one cable, for HP mostly of orange color.

Basically you are able to distinguish between the different topologies by two criteria:

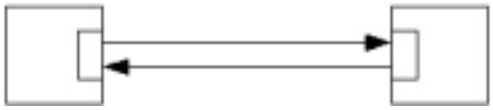
1) do we have a loop?
2) is there a swich connected?

| loop | fabric | topology |
|---|---|---|
| yes | no | private (arbitrated) loop |
| yes | yes | public loop |
| no | no | direct point-to-point |
| no | yes | switched point-to-point (*) |

(*): also known as direct fabric attach (DFA)

## Point-to-Point (P2P)

In the p2p case (no loop) two FC devices are directly interconnected with each other. The transmitting diode of one device is connected to the receiving diode of the other and vice versa. The full bandwidth can be used for data transmission. The initialization of the link (login) is quite easy. HP did only implement the switched P2P topology. P2P without fabric can be regarded as a two port loop, i.e. the overhead of the arbitrated loop protocol is used even if there are only 2 ports.

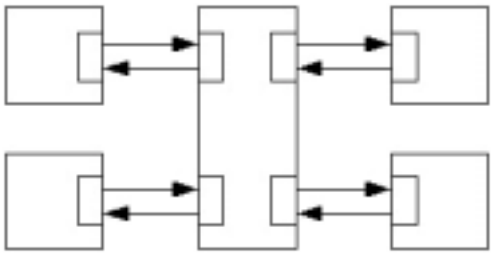


| advantages | disadvantages |
|---|---|
| dix, full bandwidth for the link | high expense in terms of hardware |
| | no scalability |

## Fabric

Using the fabric topology you can have up to $2^{24}$ (approx. 16,7 million) nodes in a meshed configuration.

The advantage of this topology is the fact that multiple devices can communicate with each other simultaneously, each granted the full bandwidth. The use of FC switches is mandatory.



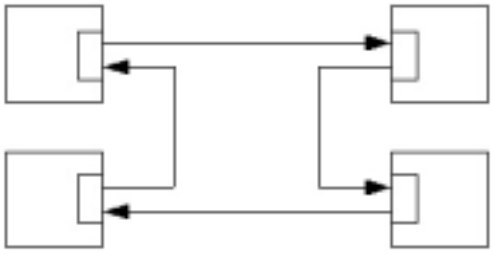
If a *N_Port* registers at a switch it is given a native address-ID (S_ID) by the switch (details in the FC addressing part). Further features of a fabric are multicast server, broadcast server, alias server, quality of service facilitator and directory server. Some switches have *FL_Ports* in order to run arbitrated loops.

| advantages | disadvantages |
|---|---|
| high scalability, i.e. many devices (up to 16 mio) | higher initial cost compared to AL |
| multiple devices communicate simultaneously | slightly lower throughput compared to AL |
| loss of one component does not interrupt the link | |
| full bandwidth for each switch port | |
| performance only minor dependant to length | |

**NOTE:**
Fabric mode is supported as of UX 11.00 Tachyon TL driver version >= B.11.00.03 and FCMS patch PHKL_21381.

## Arbitrated Loop

The Arbitrated Loop (AL) topology is able to connect up to 126 ports that share the total bandwitdh. All nodes act as loop devices.



AL is not a „token passing“ protocol. If a port within an AL likes to transmit data it needs to arbitrate the loop in order to obtain the control over the loop. It sends the ARBx signal (arbitrate primitive; x=AL_PA of the ports). When this ARBx signal returns the port has the control over the loop. After it sent the OPN signal (open primitive) to the target port, a quasi point to point connection between the two ports has been established. The other ports act as

repeater.

If more than one port arbitrates the loop at the same time, the port with the lower AL_PA (i.e. higher loop id) wins. Only if this port abandons the control over the loop, the other ports will be able to arbitrate the loop again. In contrast to a token passing protocol there is no limitation in how long a port can have control over the loop. An access fairness algorithm may be used optionally in order to give all other nodes the possibility to arbitrate the loop befor the same node gets access again..

Like most of the ring topologies the setup of an AL is simplified by using **hubs**, because standardized cables can be used. A hub is able to detect connected or disconnected devices. A faulty device or a defect cable does no longer tear down the whole network.

| Advantages | Disadvantages |
|---|---|
| cost effective | all nodes share the total bandwith |
| scalability | up to 126 nodes per loop |
| | if one component fails a new initialization is needed |
| | performance is strong dependant of length and number of nodes |

There are private und public loops.

A **private Loop** corresponds to the known implementation of the FC-AL. The adressing is done with the der AL_PA, an 8 bit identifier. All nodes in the loop can talk to each other but not to nodes outside of the loop.

In a **public Loop** the nodes register with their *World Wide Name* at the FL-port of the switch and get a 3 byte identifier assigned, i.e. they are capable of the **fabric login**. The lower byte corresponds to the AL_PA for the communication within the loop whereas the upper 2 bytes characterize the connected switchport. The name server table of the switch stores the mapping between world wide names and 3 byte identifiers. This enables public loop devices to communicate with nodes outside of the loop.

### LoopID versus AL_PA

The *Arbitrated Loop Physical Address* (AL_PA) is used for addressing within an arbitrated loop. This hexadecimal value (10 bit) is determined dynamically during initialization of the loop. The equivalent to the AL_PA is the decimal LoopID (8 bit). The table below shows the relation between LoopID and AL_PA:

| Loop ID | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00-0F** | EF | E8 | E4 | E2 | E1 | E0 | DC | DA | D9 | D6 | D5 | D4 | D3 | D2 | D1 | CE |
| **10-1F** | CD | CC | CB | CA | C9 | C7 | C6 | C5 | C3 | BC | BA | B9 | B6 | B5 | B4 | B3 |
| **20-2F** | B2 | B1 | AE | AD | AC | AB | AA | A9 | A7 | A6 | A5 | A3 | 9F | 9E | 9D | 9B |
| **30-3F** | 98 | 97 | 90 | 8F | 88 | 84 | 82 | 81 | 80 | 7C | 7A | 79 | 76 | 75 | 74 | 73 |
| **40-4F** | 72 | 71 | 6E | 6D | 6C | 6B | 6A | 69 | 67 | 66 | 65 | 63 | 5C | 5A | 59 | 56 |
| **50-5F** | 55 | 54 | 53 | 52 | 51 | 4E | 4D | 4C | 4B | 4A | 49 | 47 | 46 | 45 | 43 | 3C |
| **60-6F** | 3A | 39 | 36 | 35 | 34 | 33 | 32 | 31 | 2E | 2D | 2C | 2B | 2A | 29 | 27 | 26 |
| **70-7F** | 25 | 23 | 1F | 1E | 1D | 1B | 18 | 17 | 10 | 0F | 08 | 04 | 02 | 01 | 00 | -- |

**Example:** determine the AL_PA for **LoopID 22** (decimal):

0d22 = 0x16
LoopID can be found in 2nd row (0x10–0x1F)
7th column holds the appropriate **AL_PA: 0xC6**

The priority grows with increasing LoopID and decreasing AL_PA respectively.

So the highest priority has loop ID 126 (or 0x7E which corresponds to AL_PA 0x00). This id is reserved for a switchport (FL_Port) that may be connected to the loop. The loop ids below 126 are dynamically assigned. These so called soft addresses are used to address e.g. HBAs. Storage devices like disk arrays or tape libraries have to get fixed/hard coded loop ids because the loop id determines the hardware path and therefor the name of the device file.

# FC HBAs, Software and Patches

A Host Bus Adapters (HBA) incorporates processors to perform protocol conversion and I/O operations to off-load these duties from the host CPU. HP supports HBAs with the following 3 FC processors:

| Generation | Chip name | Topologies | FC speed | Fibre Optic Connector |
|---|---|---|---|---|
| 1 | Tachyon | FC-AL | 256Mbps/1Gbps | GLM SC connector |
| 2 | Tachyon TL/TS | FC-AL-2, P2P | 1Gbps | GBIC SC connector |
| 4 | Tachyon XL2 | FC-AL-2, P2P | 1 Gbps/2 Gbps | SFP LC connector |

**NOTES:**
GLM: Gigabit Link Module
GBIC: Gigabit Interface Converter
SFP: Small Form Factor Pluggable LC connector

The Tachyon XL2 adapter is available as of Application Release Dec 2001 (DART 55).

**Common features of all adapters are**

- Supported FC cables:
  50.0/125 (50.0µm core diameter; up to a length of 500m)
  62.5/125 (62.5µm core diameter; up to a length of 175m)
- Non-OFC, i.e. sends light (with less power) even with no cable attached
- Follows the ANSI standards for Standard Fibre Channel (X3T11)
- Fulfills the regulations of FTZ-1046 (VDE Level B)

**Features that are different are**

| Tachyon adapter | Tachyon TL/TS adapter | Tachyon XL2 adapter |
|---|---|---|
| shortwave GLM (Gigabit Link Module), interconn. for SC Duplex connector | shortwave GBIC (GigaBit Interface Converter), interconn. for SC Duplex connector | SFP (Small Form Factor Pluggable), interconn. for LC duplex conn. |
| PCI interface | PCI-2X interface | PCI-4X interface |
| supports private loops (FC-AL) only | supports private and public loops (FC-AL-2) | supports private and public loops (FC-AL-2) |
| Annual failure rate: 5.0% (A3740A), 3.4% (A3404A, A3636A), 2.0% (A3591B) | Annual failure rate: 1.7% (A5158A), 1.4% (A6684A, A6685A) | Annual failure rate: 1.0% (A6795A) |

**NOTES:**

- Tachyon TL/TS/XL2 adapter are backwards compatible and come with new features
- Tachyon TL/TS/XL2 adapter utilizise the CPUs 66% less compared to Tachyon, this results in higher system performance.
- The Tachyon adapter does not support ”fabric mode”.
- The Tachyon XL2 adapter has OLA/R support for UX 11.11 and later

HP supports the following HBAs:

| Product | FC Chip | Bus Type | Systems | OS | Lab Name | Discont. Date |
|---|---|---|---|---|---|---|
| A3404A | Tachyon | HSC | K-Class (except K100) | 10.20, 11.00, 11.11 | Baby Hugo | 09/2002 |
| A3591B | Tachyon | HSC | Dx20/Dx30/Dx70/Dx80/Dx90 R3x0/A180 | 10.20, 11.00, 11.11 | Mombasa | 06/2002 |
| A3636A | Tachyon | HSC | T600 | 10.20, 11.00, 11.11 | Baby Jade | 05/2002 |
| A3740A | Tachyon | PCI | A/L/N/V | 11.00 | KnightLite | 10/2001 |
| A5158A | Tachyon TL | PCI | Ax00/L/N/V/SD/rp8400 rx4610/rx9610 | 11.00, 11.11, 11.20(*) | Downy | 12/2002 |
| A6684A | Tachyon TL | HSC | Dx20/Dx30, A180 (**) Dx70/Dx80/Dx90, R3x0 | 10.20, 11.00, 11.11 | Bounce | tbd |
| A6685A | Tachyon TL | HSC | Kx20/x50/x60/x70/x80 | 10.20, 11.00, 11.11 | Bounce | tbd |
| A6795A | Tachyon XL2 | PCI | Ax00/L/N/SD/rp8400 | 11.00, 11.11 (64 bit only) | Doubledowny | tbd |

**NOTE** (*): only Private Loop is supported with UX 11.20, no fabric.

**NOTE** (**): these systems are supported since Application Release Dec 01 (DART 55)
for UX 10.20: since TL driver B.10.20.03
for UX 11.00: since TL driver B.11.00.10
for UX 11.11: since TL driver B.11.11.09
http://wtec.cup.hp.com/~hpux/io/current_issues/articles/100506485440883.html (HP internal)

The drivers below can be found on the application CD-ROMs/DVDs or at http://software.hp.com (below *drivers*).

To enable the fibre channel protocol you do always need the FCMS driver as a foundation:

UX 10.20:

```
J3630BA.FCMS      B.10.20.61    Fibre Channel Mass Storage Driver
```

For UX 11.X the FCMS driver is already included in Core-OS:

```
FCMassStorage     B.11.XX       Fibre Channel Mass Storage
```

The driver is patched by the Fibre Channel Mass Storage (FCMS) patch:

| | |
|---|---|
| UX 10.20 | PHSS_23581 (or newer) |
| UX 11.00 | PHKL_23939 (or newer) |
| UX 11.11 | PHKL_23626 (or newer) |

The FCMS driver enables the Tachyon chip only. In order to operate the Tachyon TL/TS or XL2 chip you additionally need to install the corresponding driver.

**UX 10.20:**

```
A6684A.FC-Tachyon-TL          B.10.20.03     HSC Tachyon TL Fibre Channel
A6685A.FC-Tachyon-TL          B.10.20.03     HSC Tachyon TL Fibre Channel
```

**UX 11.00:**

Starting with Application Release Dec 2001 (DART 55) all four TL/TS/XL2 adapters, A6684A/A6685A/A5158A/A6795A, share a common driver:

```
A6795A.FC-TACHYON-TL    B.11.00.10    PCI Tachyon TL/TS/XL2 Fibre Channel
```

The other bundles (A6684A, A6685A and A5158A) contain exactly the same product.

**UX 11.11:**

Starting with Application Release Dec 2001 (DART 55) all four TL/XL2 adapters, A6684A/A6685A/A5158A/A6795A, share a common driver. It is already included in Core-OS (version B.11.11.09 as of Dec01):

```
FibrChanl-00.FC-TACHYON-TL    B.11.11.09    PCI/HSC FibreChannel;Supptd
                                            HW=A6684A,A6685A,A5158A,A6795A
```

The appropriate patch for the Tachyon TL/TS/XL2 driver family is:

| | | |
|---|---|---|
| UX 11.00 | PHSS_23996 (or newer) | this patch is only for <= B.11.10.09 |
| UX 11.11 | PHSS_24121 (or newer) | this patch is only for <= B.11.11.06 |

Check the current support state here: http://techcom.cup.hp.com/dir_fcms/adapters.html

## Fibre Channel Kernel Driver & Tunables

The following **kernel drivers** are FC related. Some are for legacy Tachyon adapters only, some are for Tachyon TL/TS/XL2 adapters only and some are valid for all.

| Driver | Tachyon | Tachyon TL/TS/XL2 | Explanation |
|---|---|---|---|
| fcms | ✓ | ✓ | |
| fcpmux | ✓ | ✓ | if a FC-SCSI mux is used |
| fcparray | ✓ | ✓ | FCP Array Interface |
| fcp_cdio | ✓ | ✓ | |
| fcpdev | ✓ | ✓ | FCP Device Interface |
| fcT1 | ✓ | | Tachyon driver |
| fcT1_fcp | ✓ | | |
| fcT1_cntl | ✓ | | Fibre Channel Mass Storage Cntl |
| fcp | ✓ | | FCP Protocol Adapter |
| td | | ✓ | Tachyon TL/TS/XL2 driver |

There are the following **kernel tunables** are FC related. Do not modify them unless you are 100% sure of what you're doing.

| Tunable | Tachyon | Tachyon TL/TS/XL2 | Explanation |
|---|---|---|---|
| `fcp_large_ config` | ✓ | ✓ | determines whether additional memory should be allocated for FC ports. A value of 0 (default) will handle up to 64 FC ports. A value of 1 indicates that more the 64 ports may be handled concurrently. Only for Arbitrated Loop! |
| `num_tachyon_ adapters` | ✓ | | specifies how many Tachyon FCP adapters are installed in the system so that an appropriate amount of memory can be allocated for them at system start-up if the system does not provide I/O virtual addressing. Default of 0 lets the system decide. |
| `max_fcp_reqs` | ✓ | | specifies the maximum number of concurrent FCP requests allowed on any Tachyon FCP installed in the machine. Default is 512. |

See http://docs.hp.com/hpux/onlinedocs/os/KCparam.FiberchannelOverview.html for details.

**To determine which version of the drivers is installed:**

The FCMS driver:

```
# what /stand/vmunix | grep fcms
                $Revision: libtd.a:    vw: fcms    selectors: CUP11.11_BL2001_1
003 'AR1201-11i' -- ameen_2g_merged_11i 'r11.11' 'cup_td_2g_1111'  Thu Oct 11 11
:53:47 PDT 2001 $
        fcms.c $Date: 2001/01/04 10:24:48 $Revision: r11.11/1 PATCH_11.11 (PHKL
_22874)
        fcms_cdio.c $Date: 2000/12/13 15:47:27 $Revision: r11.11/1 PATCH_11.11
(PHKL_22874)
```

and additionally for Tachyon TL/TS/XL2 adapters:

```
# what /stand/vmunix | grep td
        libtd.a HP Fibre Channel Tachyon TL/TS/XL2 Driver B.11.11.09 (AR1201) /
ux/kern/kisu/TL/src/common/wsio/td_glue.c: Oct 11 2001, 11:52:36
                $Revision: libtd.a:    vw: fcms    selectors: CUP11.11_BL2001_1
003 'AR1201-11i' -- ameen_2g_merged_11i 'r11.11' 'cup_td_2g_1111'  Thu Oct 11 11
:53:47 PDT 2001 $
```

## Fibre Channel Addressing in HP-UX

The HP-UX addressing scheme assigns fixed and hierarchical hardware paths to the devices, based on the SCSI-2 specification. 14 bits are divided as follows:

| | |
|---|---|
| Bus | (7 bit = 128 busses) |
| Target | (4 bit = 16 targets) |
| Lun | (3 bit = 8 luns) |

The HW path to a SCSI disk would look like this:

```
[SCSI-HBA].[Bus].[Target].[Lun]
```

But Fibre Channel requires much more devices to be mapped:

- Every Loop can have up to 126 FC devices connected
- SAN address space is $2^{24}$ FC ports (N_Port ID is 24 bit)
- SCSI-3 standard allows up to $2^{64}$ Luns for each target (i.e. per FC port)

Therefore the FC address space has to be adapted to the HP-UX structures. This is done by expanding the HW path by 3 more fields of 8 bit each, adding 24 bit address space.

The HW path of a FC device comprises the following three parts:

```
                    additional FC fields        standard SCSI fields
[FC-HBA].[Domain].[Area].[Port].[Bus].[Target].[Lun]
```

- **HBA (host bus adapter) part**
  It depends on the slot at the host where the FC adapter card is seated.

- **Fibre Channel part (N_Port ID)**
  This part comprises of the new 8 bit fields **Domain**, **Area** and **Port**. In general these fields are used to hold the **N_Port ID**. This 3 byte value can be regarded as the equivalence to the fixed 6 byte Media-Access Control identifier (MAC address) in the LAN world. In case of a fabric topology (a switch is present) the switch assigns the N_port ID dynamically during login and stores the information it's private name server table.

  **Domain:**
  The Domain ID usually identifies the instance of the switch in a fabric environment. For private loops the value is 8.
  **Area:**
  In a fabric environment, the Area ID is generally associated with a physical port on a switch. For private loops, the value is 0.
  **Port:**
  When interpreting the hardware path for FCMS devices, arrays are defined as having addressable controllers, and non-arrays are defined as not having addressable

controllers. For hardware paths associated with non-array LUNs, the Port ID is set to the value 255 (255 for direct connect controller). For hardware paths associated with array LUNs, the Port ID is set to the Loop ID, for a private loop topology, AL_PA for public loop topology or 0 for direct fabric attach.

Domain and Area field hold the first two bytes of the N_Port ID. The third byte either comes from the Port field or from Bus and Target field of the SCSI part, depending on the addressing mode. The examples some pages ahead will help to understand this.

| Topology | Fibre Channel Part | | |
|---|---|---|---|
| | **Domain_ID (8 bit)** | **Area_ID (8 bit)** | **Port_ID (8 bit)** |
| **Private Loop** | Protocol Adapter defined in FC layer 4 (FC_4)<br>**8** for Mass Storage<br>5 for Networking | always **0** for private loop | either **LoopID**<br>or **255** in PDA addressing mode (see below) |
| **Public Loop** | usually identifies the Domain ID (i.e. **instance**) of the switch (at least for Brocade). 5 and 8 are reserved for private loop. | the physical connector (**slot**) on the switch. For Brocade subtract 16 from the Area ID to get the slot number | either **AL_PA**<br>or **255** in PDA addressing mode (see below) |
| **Direct Fabric Attach** | *same as public loop* | *same as public loop* | either **0**<br>or **255** in PDA addressing mode (see below) |

**NOTE:**
For the Brocade switches you can obtain the Domain ID of the switch either in the config menu of the front panel or when logged on via telnet using the `switchshow` command (user: admin, password: password).

- **(virtual) SCSI part**
  This part reflects the connected devices (DLTs, LUNs etc.) in a matter that HP-UX is able to access them like SCSI. The SCSI part consists of the fields Bus, Target and Lun.

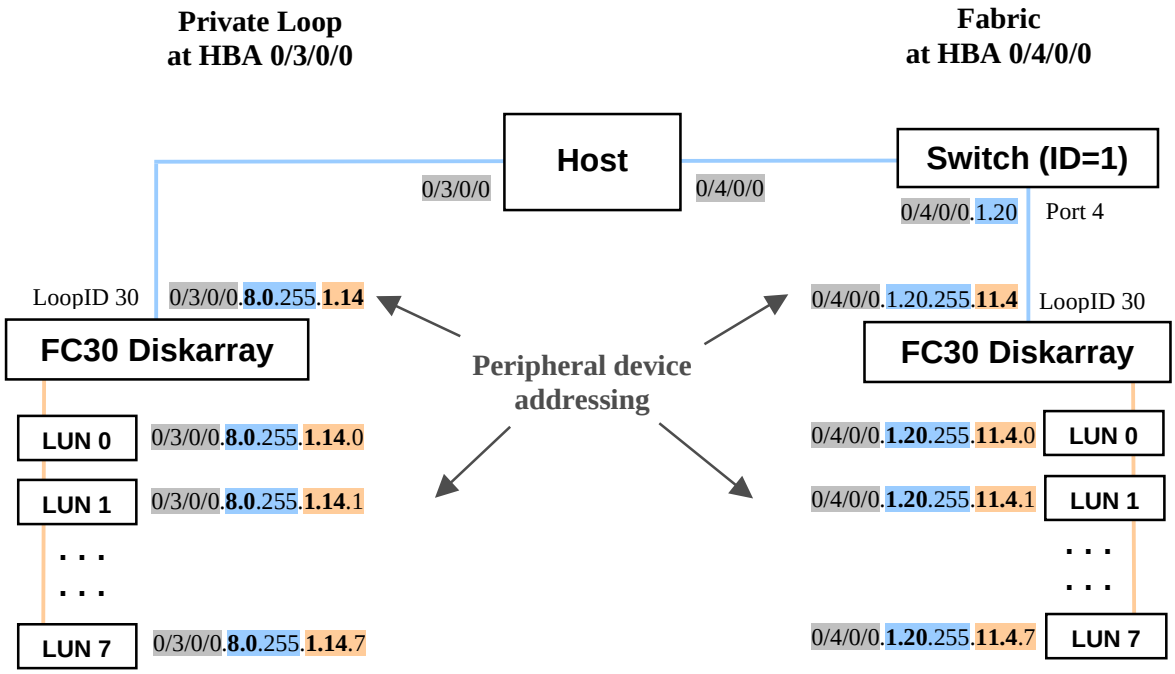
This grey blue orange color scheme will be used throughout the whole chapter in order to identify HBA, FC- and SCSI part.

HP-UX differentiates between three **addressing modes**:

- Peripheral Device Addressing (PDA)
- Volume Set Adressing (VSA)
- Logical Unit Adressing (LUN)

The driver sends out an inquiry to get the type of the device and it's capabilities. Which addessing mode to use when depends on the topology and the device.

## Peripheral Device Addressing (PDA)




This addressing mode can be identified by the fact that the Loop ID (for private loop) or AL_PA (for public loop) is coded in the fields `bus` and `target`, whereas the SCSI devices are coded in the `LUN` field. The upper 4 bits of the 8 bit Loop ID/AL_PA go to the bus field, the lower 4 bit go to the target field. So given the HW path you can calculate the Loop ID/AL_PA: 16*Bus + Target. Only the 3 bit of the Lun field are left for addressing Luns, resulting in $2^3$ = 8 possible Luns.
There is no translation at the devices behind the FC controller. This is why the `port` field is always set to 255 (i.e. direct attach). So the 255 in the port field is an indicator for PDA addressing.
PDA is the standard addressing scheme. It is used whenever there's no need to exceed 8 Luns.

**Example private loop:**

Loop ID = **30** = 0x1E ⇒ bus=0x1 = **1**, target=0xE = **14**

This results in the following HW path:

```
0/3/0/0.8.0.255.1.14.7
      |      |  |   |   |   | |_Lun
      |      |  |   |   |   |___Target  (lower 4 bits of Loop ID)
      |      |  |   |   |_______Bus  (upper 4 bits of Loop ID)
      |      |  |   |___________Port  (255 for PDA)
      |      |  |_______________Area  (0 for private loop)
      |      |__________________Domain/Protocol  (8 für Mass Storage)
      |_____________________________HBA
```

**Example public loop:**

Loop ID = 30 = 0x1E ==> AL_PA = **0xB4** ⇒ bus=0xB = **11**, target=0x4 = **4**

This results in the following HW path:

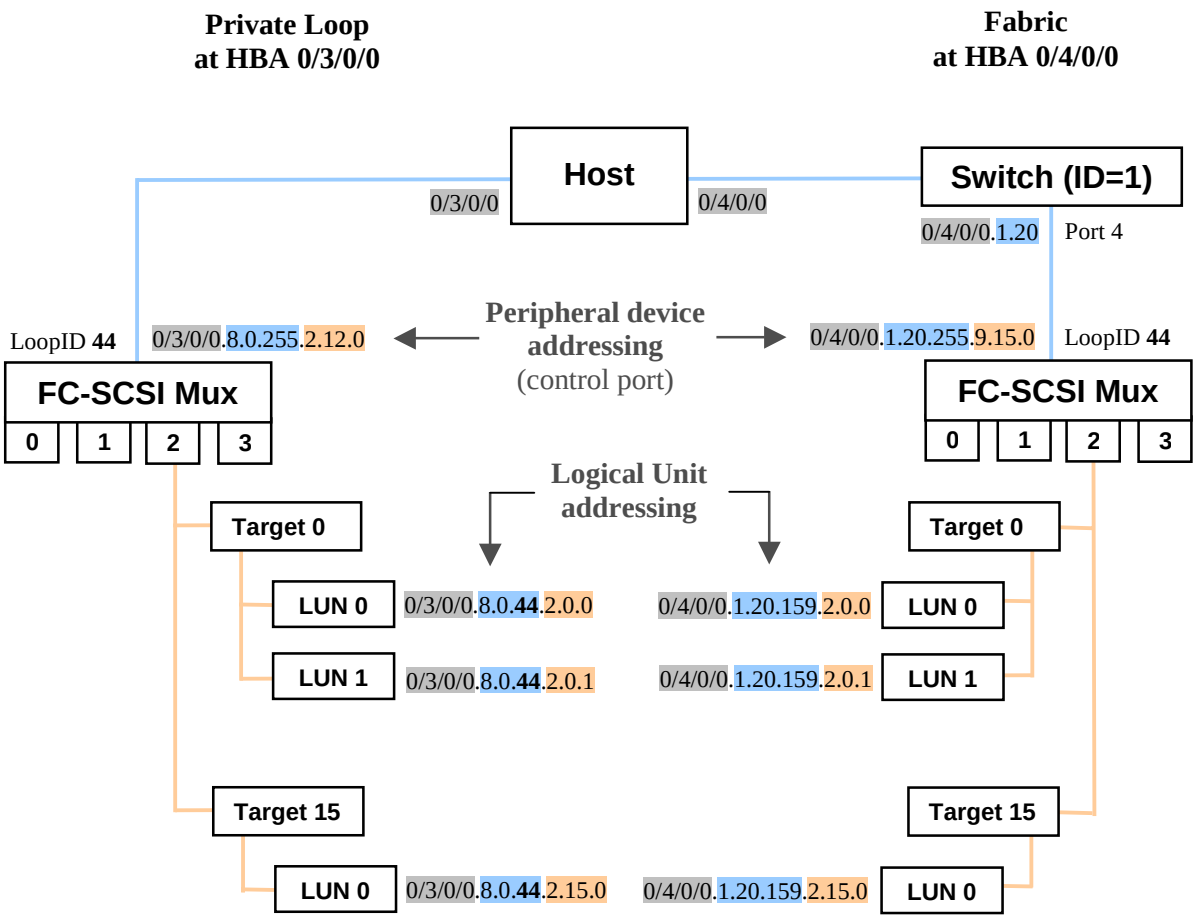
```
0/4/0/0.1.20.255.11.4.7
    |      |   |   |     |  |  |_Lun
    |      |   |   |     |  |____Target  (lower 4 bits of AL_PA)
    |      |   |   |     |_______Bus  (upper 4 bits of AL_PA)
    |      |   |   |_____________Port  (255 for PDA)
    |      |   |_________________Area  (slot at switch)
    |      |_____________________Domain  (Instance no. of the switch)
    |____________________________HBA
```

The N_Port ID is coded in the Domain field, the Area field and the AL_PA:
Domain= 1 = 0x01, Area = 20 = 0x14, AL_PA = 0xB4 ==> **N_Port ID=0x0114B4**

**PDA addressed devices are:**

- FC controller at XP, EMC, VA, FC60 disk arrays and FC-SCSI Mux
- FC4/2 bridge, FC 2/1 bridge
- Galactica DLT libraries
- FC10 disk devices
- Luns in Galaxy diskarray and Hitachi Data System (HDS) diskarray
  NOTE:
  Galaxy has no addressable controller like XP- or EMC-diskarray
  NOTE:
  although the HDS is identical to HP's XP it cannot be addressed using VSA.
  See http://wtec.cup.hp.com/~hpux/io/current_issues/articles/9962369007867.html (HP internal)

## Logical Unit Adressing (LUN)

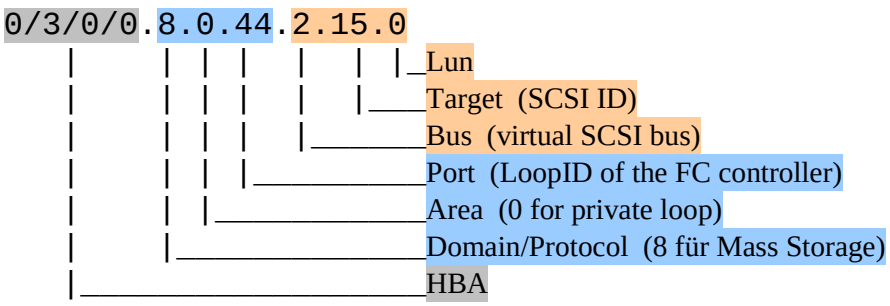



With LUN adressing mode the Loop-ID/AL_PA can be found in the Port field. Bus, Target and Lun fields are used to address SCSI devices as usual.
This addressing mode is used because the bridge does a conversion from FC to SCSI and therefore the SCSI devices are more structured. The `port` field holds at the SCSI site the Loop-ID/AL_PA of the previous component (FC-port of the FC-SCSI bridge). The `bus` field holds the instance dof the SCSI bus whereas the fields `target` (SCSI ID) and `LUN` (LUN no.) are adressed like in the SCSI world.
This addressing mode is required whenever more than 16 targets exist. The driver decides on SCSI inquiry wether LUN addressing will be used.

**Example private loop:**

Loop ID of the FC controller of the bridge = **44**

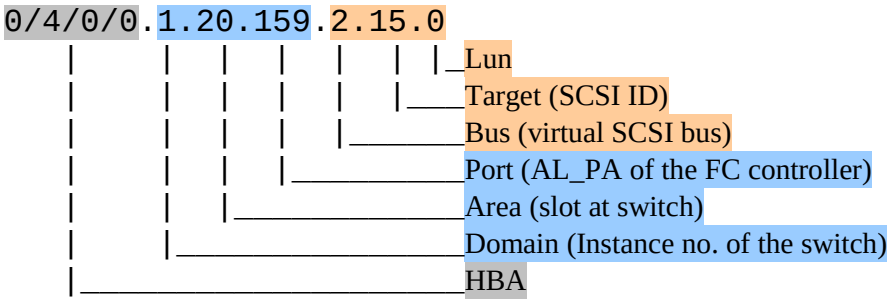
This results in the following HW path:




**Example public loop:**

Loop ID of the FC controller of the bridge = 44 = 0x2C ==> AL_PA = 0x9F = **159**

This results in the following HW path:

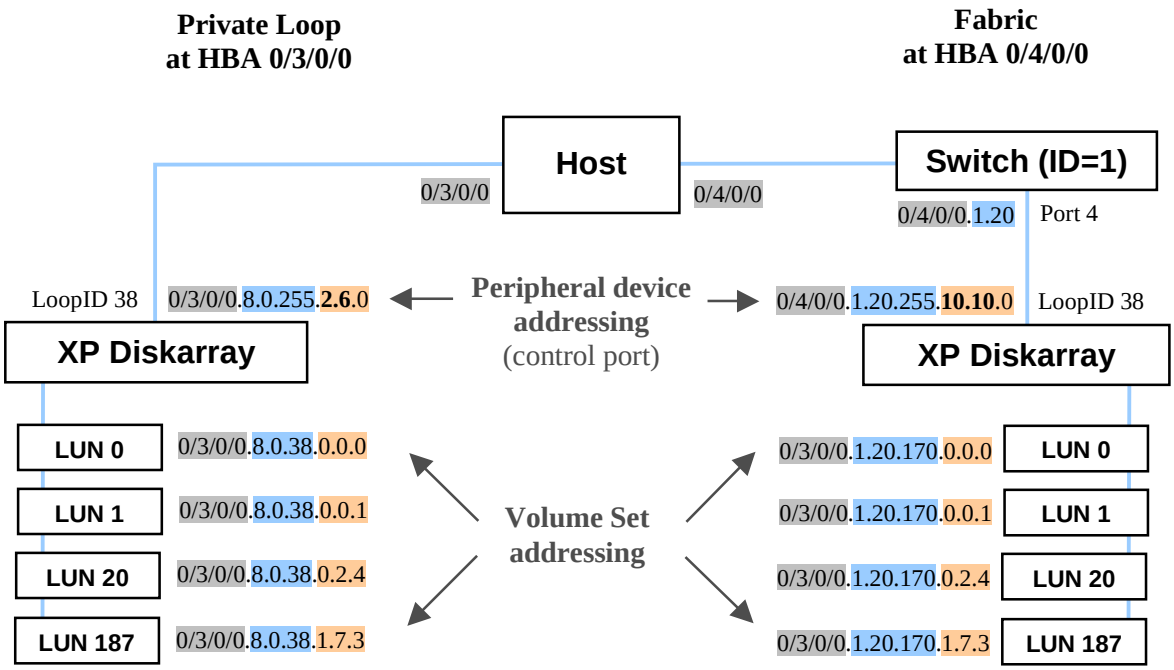



The N_Port ID is coded in the Domain field, the Area field and the AL_PA:
Domain= 1 = 0x01, Area = 20 = 0x14, AL_PA = 0x9F ==> **N_Port ID=0x01149F**

Examples for LUN addressed devices:

- SCSI interfaces of the FC-SCSI Mux and the devices behind this bus
- HP AutoRAID 12H
- XP diskarray in private loop

## Volume Set Addressing (VSA)




This addressing mode was introduced to overcome the limitation of 8 Luns for disk arrays in PDA addressing, where each Volume is mapped to a SCSI Lun of a single SCSI target. The whole 14 bits of Bus, Target and Lun field are now used for the addressing of the Luns, resulting in a maximum of $2^{14}$ = 16384 addressable Luns.
Like in LUN addressing the `port` field holds the Loop-ID/AL_PA of the previous component on the FC site (FC-Port of the disk array). The fields `bus`, `target` und `Lun` are used for the mapping of the luns, that are configured on the disk array. The driver decides on SCSI inquiry wether VSA addressing will be used.

**Example:**

The Lun number (or Volume ID) generated on an XP disk array is **187**.

Bus Target Lun
Vol ID = 187 = $(0000001\ \ 0111\ \ 011)_2$
==> Bus = $(0000001)_2$ = **1**, Target = $(0111)_2$ = **7** und Lun = $(011)_2$ = **3**

typically you calculate like this:

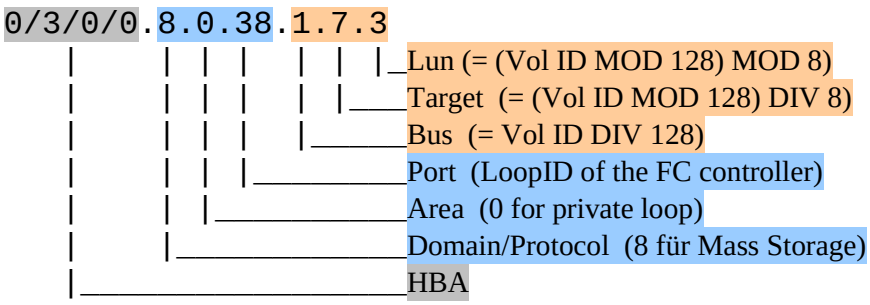
Bus = Vol ID DIV $2^7$
Target = (Vol ID MOD $2^7$) DIV $2^3$
Lun = (Vol ID MOD $2^7$) MOD $2^3$

and vice versa, starting with bus and target: and lun:

Vol ID = 128*Bus + 8*Target + Lun

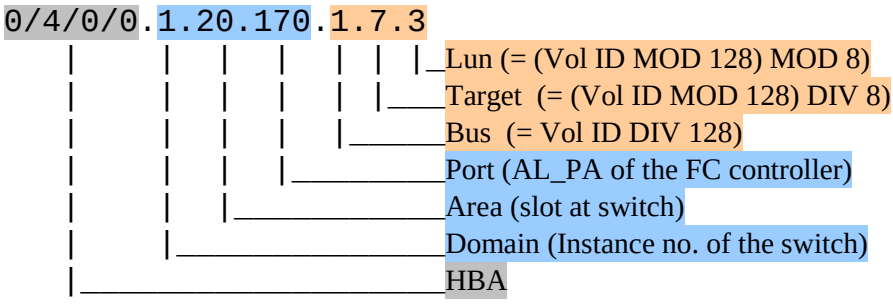
**Example private loop:**

Loop ID of the FC controller of the XP = 38.




**Example public loop:**

Loop ID of the FC controller of the XP = 38 = 0x26 ==> AL_PA = 0xAA = **170**.



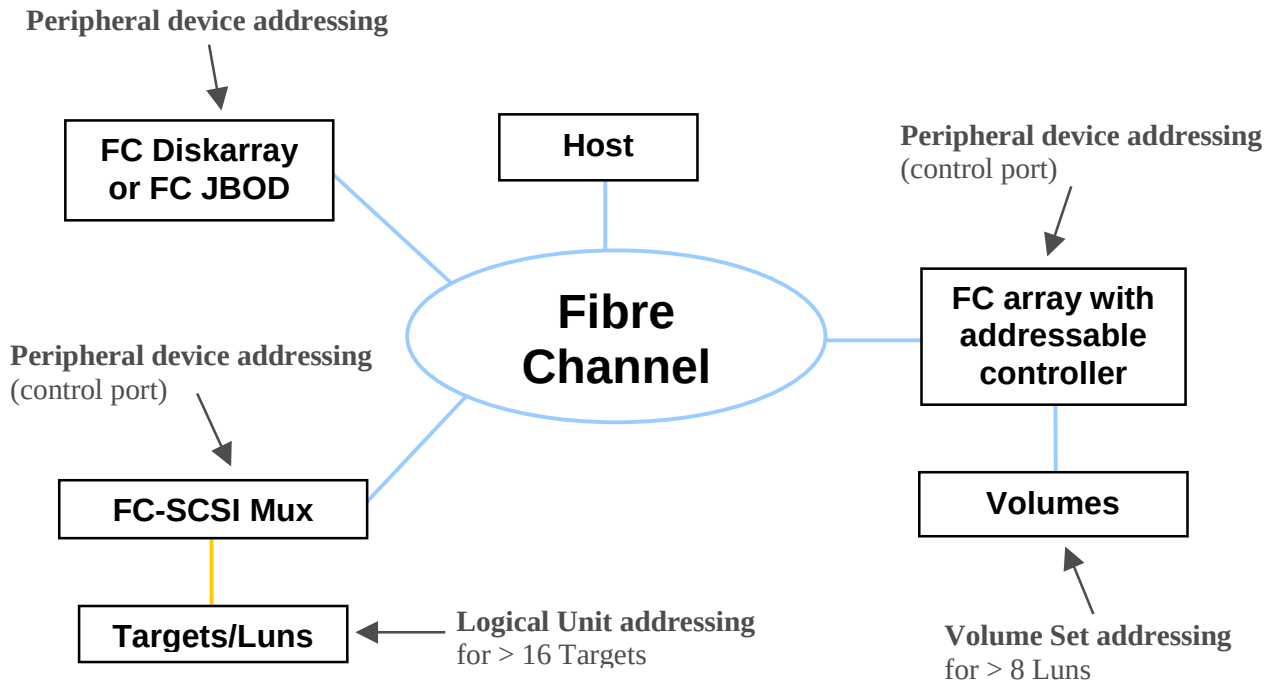

The N_Port ID is coded in the Domain field, the Area field and the AL_PA:
Domain= 1 = 0x01, Area = 20 = 0x14, AL_PA = 0xAA ==> **N_Port ID=0x0114AA**

According to PDA addressing the AL_PA is coded in the bus and target field of the HW path of the XP's control port:
AL_PA = 0xAA ==> target = 0xA = 10, bus = 0xA = 10 ==> 0/4/0/0.1.20.255.**10.10**.0.

VSA addressed devices are:

- XP-, VA-, FC60- and EMC Diskarray Volumes

The following picture summarizes the adressing modes explained above:




**some basic rules to remember resulting from the above:**

- If the **Domain ID is 8** the Area ID will be 0 and we are in a private loop, i.e without a switch.
  If the **Domain ID is not 0** it holds the ID of the attached switch and the Area ID will hold the switchport (minus 16 for Brocade) where the device is connected. The device is operating in a Public-Loop or in direct fabric attach mode (Port ID = 0)

- If the **Port ID is 255** the device is directly attached to the host over a hub or a switch and operates in PDA mode.
  If the **Port ID is 0** the device operates in **direct fabric attach mode** (if the device supports that) otherwise the Port ID holds the Loop ID for private loop or AL_PA for public loop.

- switch means fabric, hub means (private) loop

The utility “SAN Toolbox” is able to do all the above conversions. Its a Windows executable:
http://hprtnt06.grc.hp.com/central_san_cc/san_toolbox/index.htm (HP internal)

## Example: Private Loop with FC-SCSI Mux

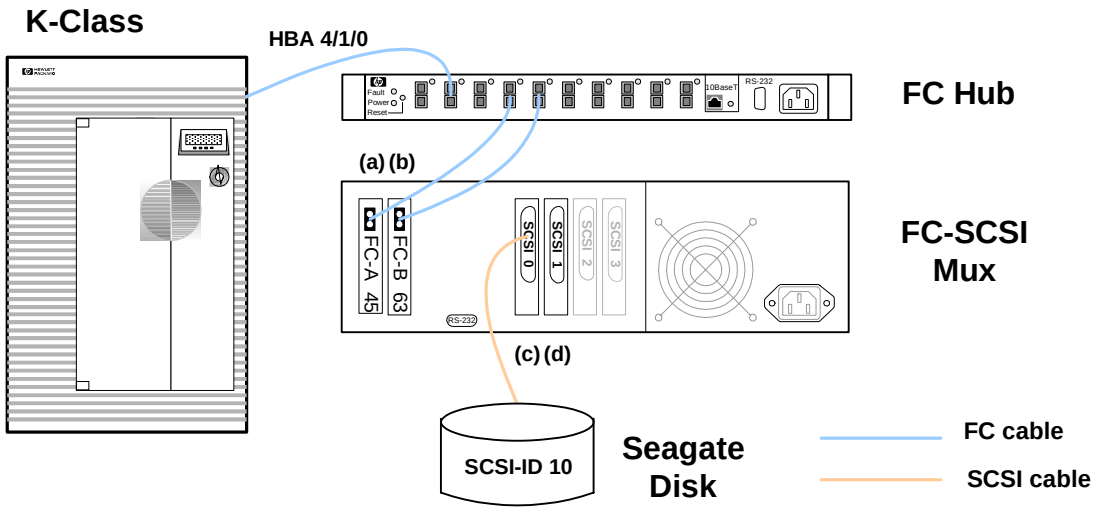
**Tachyon HBA --- HUB --- FC-SCSI Mux --- SCSI Disk**

The following example explains PDA and LUN addressing in a private loop. A FC-SCSI Mux with 2 FC adapter and 2 SCSI cards has one disk connected.

1) The FC-SCSI Mux has a unique **Loop ID** in the range 0 - 125 assigned for each of its FC adapter.
   In this example: FC Adapter A = 45, FC Adapter B = 63

2) It needs to be clear which of the 4 **SCSI Slots** (0 - 3) of the FCMS is equipped with a SCSI controller card. In this example: SCSI Slot 0, SCSI Slot 1
   The connected disk is attached to the SCSI controller in Slot 0

3) The **SCSI-ID** of the device needs to be note. For disk arrays you would also need the Lun number.
   In this example: SCSI-ID of the SEAGATE disk is 10)




How is the `ioscan` output for the above setup?

```
# ioscan -fn
...
...
ba           1  4                    epic        CLAIMED     BUS_NEXUS   PCI Bus Bridge -
epic
fc           1  4/1/0                fcT1        CLAIMED     INTERFACE   HP Fibre Channel
Mass Storage Adapter
lan          2  4/1/0.5              fcT1_cntl   CLAIMED     INTERFACE   HP Fibre Channel
Mass Storage Cntl
                                     /dev/fcms2
fcp          1  4/1/0.8              fcp         CLAIMED     INTERFACE   FCP Protocol
Adapter

(c) ext_bus      6  4/1/0.8.0.45.0    fcpmux      CLAIMED     INTERFACE   HP A3308 FCP-
SCSI MUX Interface
target       4  4/1/0.8.0.45.0.7    tgt         CLAIMED     DEVICE
ctl          5  4/1/0.8.0.45.0.7.0  sctl        CLAIMED     DEVICE      Initiator
                                     /dev/rscsi/c6t7d0
target       5  4/1/0.8.0.45.0.10   tgt         CLAIMED     DEVICE
disk         7  4/1/0.8.0.45.0.10.0 sdisk       CLAIMED     DEVICE      SEAGATE ST32550W
```

```
                                                /dev/dsk/c6t10d0   /dev/rdsk/c6t10d0

(d)  ext_bus      7  4/1/0.8.0.45.1        fcpmux      CLAIMED     INTERFACE   HP A3308 FCP-
     SCSI MUX Interface
     target       6  4/1/0.8.0.45.1.7      tgt         CLAIMED     DEVICE
     ctl          6  4/1/0.8.0.45.1.7.0    sctl        CLAIMED     DEVICE      Initiator
                                           /dev/rscsi/c7t7d0

(c)* ext_bus      9  4/1/0.8.0.63.0        fcpmux      CLAIMED     INTERFACE   HP A3308 FCP-
     SCSI MUX Interface
     target      11  4/1/0.8.0.63.0.7      tgt         CLAIMED     DEVICE
     ctl          8  4/1/0.8.0.63.0.7.0    sctl        CLAIMED     DEVICE      Initiator
                                           /dev/rscsi/c9t7d0
     target      12  4/1/0.8.0.63.0.10     tgt         CLAIMED     DEVICE
     disk         8  4/1/0.8.0.63.0.10.0   sdisk       CLAIMED     DEVICE      SEAGATE ST32550W
                      /dev/dsk/c9t10d0   /dev/rdsk/c9t10d0

(d)* ext_bus     10  4/1/0.8.0.63.1        fcpmux      CLAIMED     INTERFACE   HP A3308 FCP-
     SCSI MUX Interface
     target      13  4/1/0.8.0.63.1.7      tgt         CLAIMED     DEVICE
     ctl          9  4/1/0.8.0.63.1.7.0    sctl        CLAIMED     DEVICE      Initiator
                                           /dev/rscsi/c10t7d0

(a)  ext_bus      8  4/1/0.8.0.255.2        fcpdev      CLAIMED     INTERFACE   FCP Device
     Interface
     target       7  4/1/0.8.0.255.2.13     tgt         CLAIMED     DEVICE
     ctl          7  4/1/0.8.0.255.2.13.0   sctl        CLAIMED     DEVICE      HP    HPA3308
                                           /dev/rscsi/c8t13d0

(b)  ext_bus     11  4/1/0.8.0.255.3        fcpdev      CLAIMED     INTERFACE   FCP Device
     Interface
     target      14  4/1/0.8.0.255.3.15     tgt         CLAIMED     DEVICE
     ctl         10  4/1/0.8.0.255.3.15.0   sctl        CLAIMED     DEVICE      HP    HPA3308
```

(* means alternative link to the same device)

**Interpretation:**

**Host interface** (HBA):

```
fc  1  4/1/0  fcT1  CLAIMED INTERFACE HP Fibre Channel Mass Storage Adapter
```

**FC protocol adapter** is 8 for mass storage:

```
fcp 1  4/1/0.8   fcp    CLAIMED     INTERFACE    FCP Protocol Adapter
```

The **FC adapter** (a) and (b) of the FC-SCSI Mux are addressed in PDA mode with their Loop-IDs. In ioscan they turn up behind the devices connected to the FC-SCSI Mux:

```
(a)  ext_bus      8  4/1/0.8.0.255.2        fcpdev      CLAIMED     INTERFACE   FCP Device
     Interface
     target       7  4/1/0.8.0.255.2.13     tgt         CLAIMED     DEVICE
     ctl          7  4/1/0.8.0.255.2.13.0   sctl        CLAIMED     DEVICE      HP    HPA3308
                                           /dev/rscsi/c8t13d0

(b)  ext_bus     11  4/1/0.8.0.255.3        fcpdev      CLAIMED     INTERFACE   FCP Device
     Interface
     target      14  4/1/0.8.0.255.3.15     tgt         CLAIMED     DEVICE
     ctl         10  4/1/0.8.0.255.3.15.0   sctl        CLAIMED     DEVICE      HP    HPA3308
```

Bus and target of the FC-adapter are derived from the Loop-ID according to PDA addressing:

| for FC-A (Loop-ID 45): | for FC-B (Loop ID 63): |
|---|---|
| Bus = 45 DIV 16 = 2<br>Target = 45 MOD 16 = 13 | Bus = 63 DIV 16 = 3<br>Target = 63 MOD 16 = 15 |

The **SCSI controller** of the FC-SCSI mux and the Seagate disks behind are accessed using LUN addressing mode:

```
# ioscan -fd fcpmux
Class     I  H/W Path        Driver S/W State   H/W Type     Description
=============================================================================
ext_bus   6  4/1/0.8.0.45.0  fcpmux CLAIMED     INTERFACE    HP A3308 FCP-SCSI MUX
Interface
ext_bus   7  4/1/0.8.0.45.1  fcpmux CLAIMED     INTERFACE    HP A3308 FCP-SCSI MUX
Interface
ext_bus   9  4/1/0.8.0.63.0  fcpmux CLAIMED     INTERFACE    HP A3308 FCP-SCSI MUX
Interface
ext_bus  10  4/1/0.8.0.63.1  fcpmux CLAIMED     INTERFACE    HP A3308 FCP-SCSI MUX
Interface
```

For each FC adapter there is an entry for each SCSI card (here: 0 and 1). This lets you know the number of SCSI cards in the FC-SCSI mux. Die SCSI-ID of this cards is shown in the target field and is usually 7:

```
ext_bus      6  4/1/0.8.0.45.0        fcpmux      CLAIMED     INTERFACE    HP A3308
FCP-SCSI MUX Interface
target       4  4/1/0.8.0.45.0.7      tgt         CLAIMED     DEVICE
ctl          5  4/1/0.8.0.45.0.7.0    sctl        CLAIMED     DEVICE       Initiator
                                      /dev/rscsi/c7t7d0
```

The connected **Seagate disk** is shown straight behind this:

```
target       5  4/1/0.8.0.45.0.10     tgt         CLAIMED     DEVICE
disk         7  4/1/0.8.0.45.0.10.0   sdisk       CLAIMED     DEVICE       SEAGATE
ST32550W
               /dev/dsk/c6t10d0   /dev/rdsk/c6t10d0
```

The disk devicefile is composed of the Instancenumber of the FC-SCSI Mux SCSI cards (6), the SCSI-ID of the disk (10) and the Lun-ID (0) zusammen:

```
/dev/dsk/c6t10d0
```

In this example the disk can be accessed over a second FC path:

```
target      12  4/1/0.8.0.63.0.10     tgt         CLAIMED     DEVICE
disk         8  4/1/0.8.0.63.0.10.0   sdisk       CLAIMED     DEVICE     SEAGATE
ST32550W
                 /dev/dsk/c9t10d0   /dev/rdsk/c9t10d0
```

## Example: Private Loop versus Public Loop

Following is a simple example of migrating an HP XP256 from a private loop configuration to a fabric topology. A hub has been replaced with a switch resulting in different ioscan outputs.

**Tachyon TL/TS/XL2 HBA --- HUB --- XP256**

The ioscan output for a **Private Loop** configuration could be as follows:

```
Class     I     H/W Path            Driver     S/W State     H/W Type     Description
-----------------------------------------------------------------------------
```

```
fc       0    0/1/2/0              td          CLAIMED   INTERFACE    HP Tachyon
TL/TS Fibre Channel Mass Storage Adapter
fcp      1    0/1/2/0.8            fcp         CLAIMED   INTERFACE    FCP Protocol
Adapter
ext_bus  4    0/1/2/0.8.0.11.0     fcparray    CLAIMED   INTERFACE    FCP Array
Interface
target   6    0/1/2/0.8.0.11.0.0   tgt         CLAIMED   DEVICE
disk     3    0/1/2/0.8.0.11.0.0.0 sdisk       CLAIMED   DEVICE       HP OPEN-8
/dev/dsk/c3t0d0 /dev/rdsk/c3t0d0
disk    10    0/1/2/0.8.0.11.0.0.7 sdisk       CLAIMED   DEVICE       HP OPEN-8
/dev/dsk/c3t0d7 /dev/rdsk/c3t0d7
target   7    0/1/2/0.8.0.11.0.1   tgt         CLAIMED   DEVICE
disk    11    0/1/2/0.8.0.11.0.1.0 sdisk       CLAIMED   DEVICE       HP OPEN-9
     /dev/dsk/c3t1d0     /dev/rdsk/c3t1d0
disk    18    0/1/2/0.8.0.11.0.1.7 sdisk       CLAIMED   DEVICE       HP OPEN-9
     /dev/dsk/c3t1d7     /dev/rdsk/c3t1d7
```

**Tachyon TL/TS/XL2 HBA --- SWITCH --- XP256**

The ioscan output for a **Public Fabric Loop** configuration could be as follows:

```
Class    I    H/W Path           Driver     S/W State    H/W Type    Description
-------------------------------------------------------------------------------
fc       0    0/1/2/0              td         CLAIMED    INTERFACE   HP Tachyon
TL/TS Fibre Channel Mass Storage Adapter
fcp      1    0/1/2/0.1            fcp        CLAIMED    INTERFACE   FCP Domain
ext_bus  4    0/1/2/0.1.19.0.0     fcparray   CLAIMED    INTERFACE   FCP Array
Interface
target   6    0/1/2/0.1.19.0.0.0    tgt        CLAIMED    DEVICE
disk     3    0/1/2/0.1.19.0.0.0.0  sdisk      CLAIMED    DEVICE      HP OPEN-8
        /dev/dsk/c4t0d0       /dev/rdsk/c4t0d0
disk    10    0/1/2/0.1.19.0.0.0.7  sdisk      CLAIMED    DEVICE      HP OPEN-8
        /dev/dsk/c4t0d7       /dev/rdsk/c4t0d7
target   7    0/1/2/0.1.19.0.0.1    tgt        CLAIMED    DEVICE
disk    11    0/1/2/0.1.19.0.0.1.0  sdisk      CLAIMED    DEVICE      HP OPEN-9
        /dev/dsk/c4t1d0       /dev/rdsk/c4t1d0
disk    18    0/1/2/0.1.19.0.0.1.7  sdisk      CLAIMED    DEVICE      HP OPEN-9
        /dev/dsk/c4t1d7       /dev/rdsk/c4t1d7
fcp      0    0/1/2/0.8            fcp        SCAN       INTERFACE FCP Protocol
Adapter
```

Looking at the iotree examples, you can see the following:

There has been no change to the adapter path or the associated device file which is used for the fcmsutil diagnostic tool.

- The node 0/1/2/0.8, FCP Protocol Adapter, is in both ioscan outputs. In a private loop configuration, the interface and target devices will reside behind this node. In a Fabric environment, this node may be created as a dummy node if the HBA is scanned when it cannot see the Fabric (for example, no cable attached, switch down, etc.).

  In the original private loop implementation of the fibre channel driver, this node of the iotree was used to indicate the fibre channel FC4 “TYPE”. A type of “8” denotes that the FCP protocol is being used to encapsulate the SCSI protocol. With the introduction of fabric, this node contains the “Domain” portion of the N_Port address. To maintain backward compatibility, the domain of 8 is reserved for use with private loop devices.

  **CAUTION**
  Do not configure switches with a Domain of 8. This is an unsupported configuration and will not work. The Domain of 8 is reserved for Private Loop devices on HP systems.

- The Fabric configuration now contains an iotree node of 0/1/2/0.1 described as FCP Domain. A node of this type will be built for each Domain the Fabric contains (Domains usually correspond one to one with a switch instance).
- The FCP Array Interface iotree node has changed from 0/1/2/0.**8.0.11**.0 to 0/1/2/0.**1.19.0**.0. The address is still at hardware Path 0/1/2/0, but the next three elements of the path, which represent the N_Port address, have changed. The old N_Port address of 8.0.11 uses the reserved Domain of 8 and area of 0. In this case, the HPA or Port byte of the N_Port address is 11. In the Fabric iotree, the new N_Port address is 1.19.0. This corresponds to a Domain id of 1, an area id of 19 and a port id of 0.
  Note that for most switches, the Domain will map to a switch instance, an area id will map to a physical connector on the switch, and the port id will only be used (non zero) if there is an Arbitrated Loop configured behind the switch connector. The HPA of the device is then used as the Port portion of the iotree address.
- All targets and disk devices retain their original iotree addresses with the exception that the new Fabric N_Port address has been substituted for the old Arbitrated Loop address.
- New device files have been generated for the new iotree nodes. The old device files will continue to exist until removed with the rmsf(1M) command.

# Troubleshooting Utilities fcmsutil, tdutil, tdlist, tddiag

## fcmsutil

The `fcmsutil` utility can be found below `/opt/fc/bin/` and/or `/opt/fcms/bin`. It helps you to troubleshoot the FC Loop ot SAN. It is invoked using the device file of the FC adapter (see `ioscan -fnk`).

### Tachyon Example:

```
# fcmsutil /dev/fcms2

Local N_Port_ID is = 0x000001
N_Port Node World Wide Name = 0x10000060B03EF669
N_Port Port World Wide Name = 0x10000060B03EF669
Topology = IN_LOOP
Speed = 1062500000 (bps)
HPA of card = 0xFFB4C000
EIM of card = 0xFFFA2009
Driver state = READY
Number of EDB's in use = 0
Number of OIB's in use = 0
Number of Active Outbound Exchanges = 1
Number of Active Login Sessions = 3
```

### Tachyon TL/TS/XL2 Example:

```
# fcmsutil /dev/td0

                           Vendor ID is = 0x00103c
                           Device ID is = 0x001028
                TL Chip Revision No is = 2.3
            PCI Sub-system Vendor ID is = 0x00103c
                   PCI Sub-system ID is = 0x000006
                              Topology = PRIVATE_LOOP
                     Local N_Port_id is = 0x000001
                       Local Loop_id is = 125
            N_Port Node World Wide Name = 0x50060b0000010449
            N_Port Port World Wide Name = 0x50060b0000010448
                           Driver state = ONLINE
                       Hardware Path is = 0/3/0/0
                 Number of Assisted IOs = 47983
        Number of Active Login Sessions = 0
                    Dino Present on Card = NO
                      Maximum Frame Size = 960
                          Driver Version = @(#) libtd.a HP Fibre Channel
Tachyon TL/TS/XL2 Driver B.11.11.09 (AR1201) /ux/kern/ki
su/TL/src/common/wsio/td_glue.c: Oct 11 2001, 11:52:36
```

After pulling the FC cable the Driver state will change to:

```
                           Driver state = AWAITING_LINK_UP
```

In order to get a summary of the link statistics:

```
# fcmsutil /dev/td0 stat -s
Fri Apr 26 16:05:55 2002
Channel Statistics
```

```
Statistics From Link Status Registers ...
Loss of signal                    2     Bad Rx Char                     182
Loss of Sync                     40     Link Fail                         4
Received EOFa                     0     Discarded Frame                   0
Bad CRC                           0     Protocol Error                    0
```

Do not look for high values. Only values that are increasing over time indicate a problem.

Here's how to determine the different topologies using `fcmsutil`:

| loop | fabric | topology | fcmsutil output will be |
|---|---|---|---|
| yes | no | Private (Arbitrated) Loop | PRIVATE_LOOP/IN_LOOP |
| yes | yes | Public Loop | PUBLIC_LOOP/IN_LOOP_FL |
| no | yes | Switched Point-To-Point | IN_PTTOPT_FABRIC |

In the following we see a typical error message:

**`0/4/0/0: Unable to access previously accessed device at nport ID 0xae.`**

Here's how to troubleshoot:

```
# ioscan -fnkH0/4/0/0
fc          0  0/4/0/0                td        CLAIMED     INTERFACE    HP Tachyon TL/TS
Fibre Channel Mass Storage Adapter
                                      /dev/td0
fcp         0  0/4/0/0.8               fcp       CLAIMED     INTERFACE    FCP Protocol Adapter
ext_bus     4  0/4/0/0.8.0.255.0       fcpdev    CLAIMED     INTERFACE    FCP Device Interface
target      8  0/4/0/0.8.0.255.0.12    tgt       CLAIMED     DEVICE
disk        3  0/4/0/0.8.0.255.0.12.0  sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c4t12d0   /dev/rdsk/c4t12d0
target      9  0/4/0/0.8.0.255.0.13    tgt       CLAIMED     DEVICE
disk        4  0/4/0/0.8.0.255.0.13.0  sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c4t13d0   /dev/rdsk/c4t13d0
target     10  0/4/0/0.8.0.255.0.14    tgt       CLAIMED     DEVICE
disk        5  0/4/0/0.8.0.255.0.14.0  sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c4t14d0   /dev/rdsk/c4t14d0
target     11  0/4/0/0.8.0.255.0.15    tgt       CLAIMED     DEVICE
disk        6  0/4/0/0.8.0.255.0.15.0  sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c4t15d0   /dev/rdsk/c4t15d0
ext_bus     5  0/4/0/0.8.0.255.1       fcpdev    CLAIMED     INTERFACE    FCP Device Interface
target     12  0/4/0/0.8.0.255.1.6     tgt       CLAIMED     DEVICE
ctl         4  0/4/0/0.8.0.255.1.6.0   sctl      CLAIMED     DEVICE       HP      A5236A
target     13  0/4/0/0.8.0.255.1.8     tgt       CLAIMED     DEVICE
disk        7  0/4/0/0.8.0.255.1.8.0   sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c5t8d0   /dev/rdsk/c5t8d0
target     14  0/4/0/0.8.0.255.1.9     tgt       CLAIMED     DEVICE
disk        8  0/4/0/0.8.0.255.1.9.0   sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c5t9d0   /dev/rdsk/c5t9d0
target     15  0/4/0/0.8.0.255.1.10    tgt       CLAIMED     DEVICE
disk        9  0/4/0/0.8.0.255.1.10.0  sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c5t10d0   /dev/rdsk/c5t10d0
target     16  0/4/0/0.8.0.255.1.11    tgt       CLAIMED     DEVICE
disk       10  0/4/0/0.8.0.255.1.11.0  sdisk     CLAIMED     DEVICE       SEAGATE ST39102FC
                                      /dev/dsk/c5t11d0   /dev/rdsk/c5t11d0
ext_bus     6  0/4/0/0.8.0.255.2       fcpdev    NO_HW       INTERFACE    FCP Device Interface
```

N_port ID (= AL_PA, because it is a private loop) = 0xae
regarding the conversion table this corresponds to LoopID 34.

```
# fcmsutil /dev/td0 devstat all | grep -e Nport -e Failed
Device Statistics for Nport_id 0x0000ae(Loop_id 34)
```

```
Failed Open of previously opened device                    9
Device Statistics for Nport_id 0x0000b9(Loop_id 27)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000ba(Loop_id 26)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000bc(Loop_id 25)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000c3(Loop_id 24)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000c6(Loop_id 22)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000ce(Loop_id 15)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000d1(Loop_id 14)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000d2(Loop_id 13)
Failed Open of previously opened device                    0
Device Statistics for Nport_id 0x0000d3(Loop_id 12)
Failed Open of previously opened device                    0
```

This is a private loop with PDA Addressing (8.0.255), i.e

LoopID = 16*Bus+Target ==> Bus = 34 DIV 16 = 2
==> Target = 34 MOD 16 = 2

this results in the following HW path:

| HBA | Domain | Area | Port | Bus | Target | Lun |
|---|---|---|---|---|---|---|
| 0/4/0/0 | 8 | 0 | 255 | 2 | 2 | 0 |

This path is not part of ioscan because the interface above this path is shown as NO_HW, i.e someone disconnected it without rebooting:

```
ext_bus   6   0/4/0/0.8.0.255.2   fcpdev   NO_HW   INTERFACE   FCP Device Interface
```

A5236A is a FC10 JBOD.

### Overview of fcmsutil options

| fcmsutil Option | Explanation | T/TL |
|---|---|---|
| `fcmsutil <dev file>` | State of the link | T+TL |
| `fcmsutil <dev file> lgninfo_all` | Info about devices in the loop | T |
| `fcmsutil <dev file> devstat all` | Info about devices in the loop | TL |
| `fcmsutil <dev file> reset` | Reset the FC card | T+TL |
| `fcmsutil <dev file> lb tachyon` | Internal loopback test, tests the Tachyon chip | T |
| `fcmsutil <dev file> lb plm` | External loopback test (needs loopback cable) | T+TL |
| `fcmsutil <dev file> enable` | Enable the card (after a HW failure) | T+TL |
| `fcmsutil <dev file> disable` | Disable the card | T+TL |
| `fcmsutil <dev file> stat` | Obtain statistics maintained by the driver | T+TL |
| `fcmsutil <dev file> stat -s` | Obtain statistics summary maintained by the driver | TL |
| `fcmsutil <dev file> clear_stat` | Reset the statistics | TL |
| `fcmsutil <dev file> echo <nport_id>` | Send packet to other N-port ID (within priv. loop) | T+TL |
| `fcmsutil <dev file> rls <nport_id>` | Send packet to another N-port ID (across switch) | TL |
| `fcmsutil <dev file> replace_dsk <nport_id>` | Replace disk (disallow authentication) | TL |

T means: option available with Tachyon
TL means: option available with Tachyon TL/TS/XL2.
red font means: destructive task, i.e the communication gets interrupted.

### tdutil, tdlist, tddiag

In the directory `/opt/fcms/bin` you can find additional utilities that might be helpful:

`tdutil` this is fcmsutil but for td driver only.

`tdlist` this is a shell script that uses ioscan and tdutil in order to list all devices that are are handled by the td driver, i.e. all devices attached to the Tachyon TL/TS/XL2 adapters on the system. The script contains a nice function that translates Loop ID to AL_PA.

`tddiag` this is a shell script that gathers the following fibre channel related information of the system:
system name, system model, system uptime, memory information, mounted file systems, TachLite version in kernel, system file, patches installed, device special files for TachLite, ioscan output, tdlist output, running processes,
infos about each /dev/td#:
device info, device vpd info, device topology sensing mode, chip registers, device statistics, Name Server device statistics, CT Server device statistics, all remote statistics, name server port info (from kernel), name server port info (from switch), device statistics on all targets.

## How to Replace Disks at Tachyon TL/TS/XL2 HBAs

Before a server can talk to a target it has to authenticate at the Tachyon TL/TS/XL2 HBA with its WWN (World Wide Name). This authentication (PLOGI) ensures that the system is talking to the correct device, avoiding data corruption due to user accidentally connecting another device at the same nport_id.
The **Adapter** holds a table where the native address (S_ID or AL_PA and WWN) of every known device of the loop is stored. This table is created upon initialization of the link or when the first communication between host and device happens.

**NOTE:**
This authentication applies to the devices connected to the TL/TS/XL2 adapter only, Tachyon adapters do not go through the same level of authentication. (replace_dsk option is supported by TL/TS/XL2 only).

The replace_dsk option of fcmsutil is neccessary in order to change a device and keep the same nport_id but primarily, it should be used when replacing a bad disk. When this option is used, no authentication on that device is performed the next time system communicates with it thus avoiding the following error (syslog):

```
0/4/0/0: 'World-wide name' (unique identifier) for device at loop ID
```

```
0x5 has changed. If the device has been replaced intentionally, please
use the fcmsutil replace_dsk command to allow the new device to be
used.
```

In this example the disk with loop_id 5 at Tachyon TL/TS/XL2-Adapter /dev/td0 is going to be replaced:

- Identify the nport_id or loop_id of the disk being moved or replaced

  (this step is optional if nport_id or loop_id of the device is known from syslog, dmesg, or other error logs)

  Disconnect device (i.e remove it from the loop)

  List all devices with which the TL/TS/XL2 card has successfully communicated using the devstat all option:

  ```
  # fcmsutil /dev/td0 devstat all | grep Loop
  Device Statistics for Nport_id 0x0000E8 (Loop_id 1)
  Device Statistics for Nport_id 0x0000DA (Loop_id 5)
  ```

  Using the echo option, try to login to each device using the loop_id, a message "unable to login" is returned for the disconnected device.

  ```
  # fcmsutil /dev/td0 echo -l 1
  Data came back intact
  ...
  # fcmsutil /dev/td0 echo -l 5
  Unable to login
  ```

- Run replace_dsk using nport_id:

  ```
  # fcmsutil /dev/td0 replace_dsk 0x0000DA
  ```

  in a private loop you can also use the loop_id:

  ```
  # fcmsutil /dev/td0 replace_dsk -l 5
  ```

  After running the above command, you will get a message indicating the port will not be authenticated:

  ```
  Disk at nportid 0x0000da (Loop_id 5) will not be authenticated
  ```

  **ATTENTION:** This step has to be repeated for **any** Tachyon TL/TS/XL2 adapter on the host as well as for other hosts (e.g in a ServiceGuard cluster) that access the same device!

- Replace bad disk with new disk

The new disk (loop_id=5) now can login without getting an authentication failure. The next time the system issues any read/write operations (e.g. ioscan) to the new disk, the new World-Wide Name (WWN) will be recognized and recorded to associate with nport_id 0x0000da.
It is important to make sure the correct nport_id or loop_id is used with replace_dsk but if you accidentally type in the wrong nport_id or Loop_id, nothing catastrophic will occur. Just keep in mind that there will be no authentication done on that device during the next login. The device will be authenticated on subsequent logins.

# Fibre Channel Storage Devices

This is just a short overview about existing devices. If you need details got to HP's storage website http://www.hp.com/go/storage or follow one of the links at section Additional Information.

### NIKE Model 30 FC Disk Array (legacy)

| | |
|---|---|
| Product Name: | 30 Slot Fibre Channel Disk Array |
| Codename: | „Galaxy" |
| Product No.: | A3661A |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/7/psp7901.htm (HP internal) |

**NOTE:** This is a legacy product which should not be ordered anymore.
For details go to the NIKE Disk Array Chapter.

### FC10 Fibre Channel Disk System (legacy)

| | |
|---|---|
| Product Name: | HP SureStore E Disk System FC10 |
| Codename: | „Transformer" |
| Product No.: | A5236A |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/9/psp9335.htm (HP internal) |

The HP SureStore E Disk System FC10 is a 10-slot Fiber Channel JBOD Disk Enclosure that features redundant Link Control Cards (LCC), redundant power supplies and fan modules. The disk modules are native Fibre Channel with 2 FC-ALports per disk. This allows the use of alternate paths for high availability configurations.

### FC60 Fibre Channel Disk Array

| | |
|---|---|
| Product Name: | High Availability Fibre Channel Disk Array Model 60/FC |
| Codename: | „Optimus Prime" |
| ProductNo.: | A5277A |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/10/psp10230.htm (HP internal) |

High availability disk array comprised of a controller enclosure and up to six disk enclosures. Each disk enclosure can contain up to ten disks. Disk capacities are 18.2GB, 36.4GB or 73.4GB. RAID Level 0*, 1, 5, and 0/1 are supported.
The HP Array Manager/60 cumulative Patch provides the Manager Software in order to administer the FC60. It contains the commands with manual pages and the startup script (`/sbin/init.d/hparamgr`). The commands can be found in the directory `/opt/hparray/bin/`:

`amdsp`, `amcfg`, `amdload`, `amfmt`, `amlog`, `ammgr`, `amutil`.

The communication with the array is done by a daemon (`/usr/lbin/hparray/hparamgrd`) that is invoked by the startup script.

**NOTE:** The administration of the FC60 is nearly identical to the administration of an AutoRAID.

HP Array Manager/60 Patch:

| | | |
|---|---|---|
| UX 10.20 | PHCO_23148 | (or newer) |
| UX 11.00 | PHCO_23149 | (or newer) |
| UX 11.11 | PHCO_23150 | (or newer) |

To administer the FC60 through SAM you need at least the following SAM patch:

| | | |
|---|---|---|
| UX 10.20 | PHCO_19046 | (or newer) |
| UX 11.00 | PHCO_21267 | (or newer) |
| UX 11.11 | not necessary | |

Manual Pages:

amdsp(1M), ammgr(1M), amcfg(1M), amutil(1M), amlog(1M), AM60Srvr(1M).

### XP Disk Array Family

| | |
|---|---|
| Product Name: | HP SureStore E Disk Array XP512 |
| Codename: | „Orca” |
| ProductNo.: | A5950A |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/11/psp11235.htm (HP internal) |

| | |
|---|---|
| Product Name: | HP SureStore E Disk Array XP48 |
| Codename: | „Cuda” |
| ProductNo.: | A5920A |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/11/psp11559.htm (HP internal) |

Information can be found in the XP Disk Arrays Chapter.

### HP Virtual Array VA7100/VA7400

The HP Virtual Array VA7100 and VA7400 are utilizing AutoRAID technology. All modules front and rear are hot pluggable.

| | |
|---|---|
| Product Name: | HP Virtual Array VA7100 |
| Codename: | „Cassini“ |
| ProductNo.: | VA7100 |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/11/psp11761.htm (HP internal) |

The chassis accomodates:

- 3 EIA rack mountable chassis.
- 15 low profile 3.5 inch fibre channel hard disk drives loaded from the front.
- 1 or 2 fibre channel controllers mounted in the rear. Each controller has one 1Gb fibre channel interface to the host.
- 2 power supply and fan modules mounted in the rear. The power supply and fan components are combined into a single module.

| | |
|---|---|
| Product Name: | Virtual Array VA7400 |
| Codename: | „Cronus“ |
| ProductNo.: | VA7400 |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/12/psp12062.htm (HP internal) |

Compared to the VA7100 this array has the following additional features:

- Two types of chassis enclosures: The main that holds the AutoRAID controllers and

up to six add on enclosures that allow more drives to be added behind the AutoRAID controllers.
- Optional 2Gb configurable fibre channel interface to the host
- Add on chassis has 2 fibre channel LCC (Link Controller Card) that allows a daisy chain type of connection to the main. Each LCC has two 1Gb fibre channel interface.

You can manage the VA either by the front panel or by installing a is a graphical + command line user interface - HP Command View SDM. The administration of the VA is similar to the administration of the FC60 or the AutoRAID. The commands start with `arm*` instead of `am*` or `array*` at the FC60 or AutoRAID respectively. The table at http://ren.nsr.hp.com/howto/array.html (HP internal) gives you a comparison between the admin commands of the three disk arrays.
You can download SDM from an external website. Just search for "sdm ux" at http://www.hp.com. It can also be found (together with latest Firmware) at the HP intranet: http://tce-web.boi.hp.com/prod_port/ (HP internal).

### HP SureStore Disk System 2405 (ds2405)

| | |
|---|---|
| Product Name: | HP Surestore Disk System 2405 |
| Codename: | „Apex“ |
| ProductNo.: | A6250A |
| PSP: | http://wwwpsp.atl.hp.com/lmx_mount/supplan/psp/12/psp12704.htm (HP internal) |

The HP Surestore Disk System 2405 (ds2405) supports the latest 2 Gb Fibre Channel technology. With its modular design, the ds2405 is a highly scalable and flexible storage system. In a compact 3U form factor, each enclosure holds up to 15 disk drives or over 1 TB of capacity. The ds2405 can be upgraded from a standalone disk system to add-on storage for the HP Virtual Array.

# Glossary

| | |
|---|---|
| **AL_PA** | ArbitratedLoop_PhysicalAddress; The address of a fibre channel node in an *arbitrated loop*. (1byte; 0x00..0x7E) |
| **Arbitrated Loop** | An interconnection scheme which supports up to 126 ports on a loop in a shared medium topology. This is HP's standard implementation of a loop Same as *FC-AL*. |
| **Cascading** | An interconnection of individual switches used to create larger Fabric configuration. |
| **DFA** | Direct Fabric Attach - the connection between an N-port and an F-port. |
| **E-Port** | Switch port to cascades switches. |
| **EPL** | Enhanced Private Loop; HP's FC-AL implementation with limitations in order to use legacy devices (FC-devices in *PLDA* environment; e.g. Galaxy Disk Array) in a SAN but access them like *PLDA*. |
| **F-Port** | Switch Port that operates according to the *P2P* protocol. |
| **Fabric** | A fibre channel interconnection method which allows multiple hosts and/or storage devices connected with a multi-port hub allowing multiple, simultaneous and concurrent data transfers. The existance of a FC switch is fundamental. |
| **FC-AL** | Abbreviation for Fibre Channel Arbitrated Loop; see *Arbitrated Loop*. |
| **FC-AL-2** | Whereas FC-AL allows private loop only, FC-AL-2 allows private and public loop. In order to run public loop the device needs to be able handle 8 bit addresses within the private loop (FC-AL) and 24bit addresses when communicating over the switch. |
| **FC-FLA** | FC Fabric Loop Attach; ANSI standard that describes the communication between *NL*- und *FL-Ports*. |
| **Fibre** | Thin filament of glass. An optical wavequide consisting of a core and a cladding which is capable of carrying information in the form of light. Fibre is also a general term used to cover all physical media types supported by Fibre Channel, such as optical fiber, twisted pair, and coaxial cable. |
| **Fibre Channel** | A high-speed, serial, bi-directional, topology independent, multi-protocol, highly scalable interconnection between computers, peripherals, and networks. |
| **FL-Port** | Switch port that operates in Loop protocol. |
| **Frame** | Smallest unit of the transmission protocol between 2 N-Ports. It consists of start sequence, header, payload (SCSI data), CRC and end sequence. |
| **ISL** | Inter Switch Link. A cable to cascade FC switches. |
| **Loop** | All nodes are attached in a ring topology (similar to FDDI or Token Ring). |
| **Loop ID** | Counterpart to AL_PA. Address of the node in *FC-AL* (126 to 0). |

| | |
|---|---|
| **N-Port** | Port of a storage device or host that operates according to *P2P* protocol. |
| **NL-Port** | A storage device or host that operates according to *FC-AL* protocol. |
| **Node** | Device that is connected over fibre channel (host, disk array, bridge, …). |
| **P2P** | Point-To-Point; direct connection between two nodes. |
| **PLDA** | Private Loop Direct Attach (synonym: private loop). |
| **Port** | FC-interconnection of a node. Ususally means node. |
| **Private Loop** | A private loop is an *Arbitrated Loop* which has no attached switch port (NL-port to NL-port). In theory, private loop devices can only communicate with other devices on the same loop, but see *Translative Mode*. |
| **Public Loop** | Arbitrated Loop with a switch port (FL-Port) that allows the nodes to communicate with other nodes outside the loop. |
| **QL** | Quick Loop - a technique by which a Brocade switch can combine several fibre channel links into a single virtual private arbitrated loop. |
| **TranslativeMode** | A technique by which a switch allows private targets which only speak the private loop protocol to communicate with public initiators which are not actually on the loop. The switch creates the illusion that these private targets physically connected via private loop ports are on the fabric, by creating "phantom" fabric addresses which can be the source or destination of messages. The switch sees and captures these messages and reroutes them to the correct address. |

## Additional Information

The technical development on the fibre channel market is fast and rapidly growing. Answers to questions regarding supported configurations and newest technology can be found on the following websites:

**HP's current state of FC support**
http://techcom.cup.hp.com/dir_fcms/supinfo_index.htm
http://turbo.rose.hp.com/spock (HP internal)

**EMEA Central SAN Competency Center**
http://hprtnt06.grc.hp.com/central_san_cc (HP internal)
this site contains very good training material! It links to the good old *Tachyon Times* website.

**WW Storage Support Portal**
http://invent.atl.hp.com/WWStoragePortal/ (HP internal)

**Manuals and Release Notes**
http://docs.hp.com/hpux/netcom/#Fibre%20Channel

**Fibre Channel Association**
http://www.fibrechannel.com (non HP)