Presentation #1006

Fibre Channel, For the Long Run

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What is Fibre Channel?

Today's emerging architecture, performance, and implementation demands are causing existing methods of data transport to encounter the limits of their capabilities. According to Amdahl's law, a megabit per second of input/output (I/O) capability is needed for every MIPS of processor performance. The two basic types of data communications connections, *networks* and traditional *channels*, are inadequate to meet that requirement. Some of the limitations related to media dependency, distance and addressability are:

Distance constraints that preclude broadly distributed systems
Speed constraints
Connector footprints that are too large for shrinking systems and peripherals
Physical incompatibility that prohibits connectivity
Restrictions on the number of nodes (processors or peripherals) that can be accommodated

Fibre Channel was developed to overcome those limitations by providing a flexible, high-performance, yet low-cost interface that will allow both existing and future systems to communicate at gigabit-per-second data rates. The goals set for Fibre Channel are:

To combine the benefits of channel and network technology
To provide a transparent transport of multiple, well-known channel and network protocols over a single physical interface
To accommodate several different types of physical interfaces and a means by which to interconnect them
To provide for very high speed transfer of information

In concept, Fibre Channel is a channel/network hybrid, combining the simplicity, predictable performance and guaranteed delivery of a channel with the high connectivity, long distance and protocol multiplexing of a network. It is capable of moving large amounts of data at the fastest possible speed with the least possible delay.

In application, Fibre Channel is the implementation of a new set of ANSI standards which cover networking, storage and data transfer in order to provide a media-independent, device-independent, application-independent protocol.

The use of Fibre Channel is frequently likened to a telephone system. Any telephone that uses a standard phone connection can be plugged into a phone jack:

"When a caller picks up a telephone and dials a number, the telephone company routes the call and makes all the intermediate connections needed to ring the number dialed. If the phone is answered, the route is confirmed all the way back to the caller. If a switch or cable fails along the way, the telephone company re-routes calls onto other circuits. Error recovery is the responsibility of the phone company, not the caller, who is usually completely unaware that anything unusual is happening." [1]

The Fibre Channel standard addresses all of the elements necessary for this kind of flexibility -- dynamic connection, type and speed of connection, distance, guaranteed delivery, receipt acknowledgment, and so forth. It provides:

> High-speed interconnection, communication and data transfer
> Among heterogeneous systems and peripherals including workstations, mainframes, supercomputers, desktop computers, storage devices and display devices, and
> Handles both networking and peripheral I/O communication over a single channel using common drivers, ports and adapters. [1]

Fibre Channel is very fast -- 10 to 250 times faster than typical LAN speeds today. It can transmit at rates exceeding 100 megabytes per second, the equivalent of 60,000 pages of text per second. [2] A single link can be as long as 10 kilometers.

Why Is It Better Than the Current Alternatives?

Fibre Channel is unique because it provides a single standard interface that supports both channel and network connections using multiple protocols. Existing protocols, IP, IEEE 802, ATM, HIPPI, IPI-3, SBCCS, SCSI can be transported using Fibre Channel. The ANSI standards provide for mapping each of these protocols.
This ability to map and transport without additional overhead allows users to protect their investment in existing network and channel software and devices while gaining the connectivity, speed and flexibility of Fibre Channel.

"The Fibre Channel standards support a wide range of link technologies, distances, and bandwidths. These include those at the leading edge of the technology, providing new application opportunities requiring such high data rates and distances. Additionally, Fibre Channel is structured to take advantage of further technological advances such as higher bit rates and advances in wave division multiplexing.

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[1] "Emulex Fibre Channel Information Series", Volume 1, Emulex Network Systems™

[2] Fibre Channel Association "Fibre Channel Systems Initiative".

"Existing applications, not necessarily requiring high data rates, also attain significant benefits due to the multiplexing capabilities provided in the standard. These capabilities permit a high level of port and link sharing, thereby enabling a significant reduction in the number of ports and links to support a given system throughput.

"Finally, the ability of Fibre Channel to replace the separate and distinct interconnects used by peripherals, coupled with its ability to transport network traffic, allow it to be truly mass-marketed. The resulting large volumes drastically reduce costs. It is conceivable that Fibre Channel is the only interface that a system needs for these attachments."[3]

How Should Fibre Channel Be Used?

The multiple, mixed needs of a campus or enterprise can be met by Fibre Channel. [4]

In an Information Technology implementation, Fibre Channel can provide a network backbone, carrying the connection between network controllers and among loops (see "Fibre Channel Topologies" chart).

Workstations and peripherals can be connected to one another. High resolution graphics and video displays can be shared. Clusters of workstations can be connected to create a parallel computing environment.

Fibre Channel is well-suited for mass storage management, allowing shared disk access with reduced wiring requirements. Several media are specified in the standard, including copper, making disk arrays with hot insertion capability possible. The disks form an enclosed arbitrated loop, and the arrays can be attached using fiber optic cable directly to systems. Intelligent mass storage amounting to terabytes of data can be made available to multiple computing devices simultaneously.

Fibre Channel can be used for real-time backup operations. Using Fibre Channel, data can be backed up as frequently as needed directly to a mass storage device at a secure remote location, greatly simplifying the catastrophe plans of any large corporation.

Applications

Shared computing power: Link mainframes, minicomputers, workstations and personal computers to high-speed networks over large campuses.

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[3]http://www.prz.tu-berlin.de/docs/html/EANTC/INFOSYS/fibrechannel/detail/FCOverview.html

[4]Fibre Channel Association presentation material.

Clustering: Allow full exploitation of clustered computing without the restrictions of Ethernet, Token Ring or FDDI.
Shared mass storage: Provide access to central mass storage in the form of large disk arrays, both magnetic and optical.
Mirrored or Shadowed mass storage: Give continuous access to data for uninterrupted operations.
Image-based document management systems: Allow forms to be scanned directly into the computer and stored as images. High-speed optical links provide rapid retrieval of data-intensive visual information.
High-speed serial communication: Permit real-time video conferencing between workstation users, multimedia applications employing voice, music, animation and video.
On-line consultation: Provide simultaneous transmission of images such as magnetic resonance scans to hundreds of workstations throughout a campus.

Categories of Applications

	Markets	Applications	Benefits
Decision Support *(slow transfer, small data structures)*	Finance Banking Insurance	Sales Analysis Customer Profiles Data Warehousing	Response Time
Transaction Processing *(fast transfer, small data structures)*	Telecom Finance/Banking Manufacturing	Payroll/Credit Customer Service MRP/Shop Floor	Faster OLTP
Compute/Analytic *(slow transfer, large data structures)*	Aerospace Automotive Oil & Gas Scientific	Computer-aided Engineering Finite Element Analysis Seismic Analysis	Collaborative Engineering Data analysis
Emerging Markets *(fast transfer, large data structures)*	Medical Video, voice Multimedia	Medical Imaging Video-on-demand Visualization	Collaborative Diagnosis Large data volume

Platforms and Applications [5]

Because Fibre Channel is device-independent, applications can be tailored to existing or planned platforms.

Platform	**Application**
Workstation Clustering	CAD/CAM Publications Medical Imaging Video Editing
Network Storage Server	Remote Mass Storage RAID Attach
SMP Clustering	Remote Mass Storage Video Conferencing Reservation Systems Scientific Simulation
Campus Network	Remote Mass Storage Remote Inter-processor Communication Video Conferencing

What Are the Requirements for Using Fibre Channel?

[5]Symbios Logic Product Overview

First, some basic terminology:

Fibre Channel devices are called **NODES.**

Each node has at least one **PORT,** also referred to as an **N_PORT,** to provide access to the outside world.

Each port uses a pair of **FIBERS** -- one for information in, one for information out.

Each pair of fibers is called a **LINK**.

The elements shown in the illustration below are required to establish a Fibre Channel connection.

HOST AND TARGETS:

A Fibre Channel connection is always established between two NODES. The HOST end of the connection will be a computer, CPU or SPU, and include the operating system and Fibre Channel drivers. The other node of the connection is commonly known as the TARGET. It can be any of several types of devices, including switches and routers, multiplexers, and directly attached Fibre Channel mass storage. Switches and mass storage devices that use Fibre Channel as their connection mechanism are being developed now by several peripheral providers.

ADAPTERS: A Fibre Channel ADAPTER will be installed in the HOST to accommodate the physical connectors.

LINK and Connectors:

Fiber optic cabling is necessary to provide the physical LINK between nodes. Fiber optic media consists of a pair of fibers, one for each direction, allowing a single connector but providing full duplex operation. Each end of the LINK includes a physical connector. For a link, the connectors must be of the same type and speed at each end (see "Laser Types and Speeds" chart) . Therefore in order to implement Fibre Channel, devices which can interconnect are required.

Software Requirements

Depending on the Fibre Channel adapter and peripheral vendor(s) chosen, certain versions of the operating system may be required. The same is true of device drivers. Existing application and system management software should not require changes.

System Management Tools

The diagram below illustrates what is known as a *fabric* configuration (see the "Fibre Channel Topologies" Chart). Each individual node (*N_Port*) is connected in a physical point-to-point, dedicated connection to a Fibre Channel switching device (*fabric port or F_Port*). While each device interacts with the fabric independently, the whole fabric can be controlled from one CPU (host).

With the proper administration utility, fabric administration can be managed through a central tool on the designated host. Status information of all nodes can be available through the same tool. In case of a node failure, the failing device can be pinpointed and troubleshooting can occur either from the host or at the local device.

An intelligent fabric administration tool will include diagnostics, and will provide sufficient information about activities in the fabric so the true state of devices is obvious. Quite often the corrective action is a device reset for a device which appears to be "hung" . In a Fibre Channel fabric, it is essential to know whether the device is actually hung or just busy, to avoid spurious resets and other actions which interrupt operations. A good tool will provide that information.

Any vendor who provides Fibre Channel solutions should also provide administration tools. Fibre Channel is implemented in hardware with software drivers; these drivers must be compatible with the operating system, and should link into existing system administration tools.

What Plans and Changes Will Be Needed?

The following illustration is a way to represent a Fibre Channel fabric topology in terms of hardware and peripheral placement and connections. To use Fibre Channel effectively, especially in the larger fabric configurations, greater initial planning is required. Good "system maps" are essential.

Depending on the complexity of the configuration to be installed, the following are recommended:

Contracted site preparation consultation, which should include determination of the best type of Fibre Channel media for the intended purpose (see "Laser Types and Speeds" chart).

Professional installation of the main nodes on the fabric. Main nodes would be the primary hosts, the fabric controller (switch) if one is used, multiplexer if one is used, and primary mass storage.

Review of system administration software tools for completeness and usability for the planned configuration.

In addition, fiber optic media management will be required, which may necessitate the use of subcontractors for installation and maintenance of the fiber optic media. In some applications, it may be possible to use existing FDDI cabling (FDDI equates to 62.5 micrometer short wave laser). Although the difference in laser types between

FDDI and Fibre Channel may cost the user distance capability, that can be offset by the savings in re-cabling a facility for Fibre Channel.

Use of Existing Equipment

It's important to determine usage and placement of switches, multiplexers and mass storage from the standpoint of any existing equipment as well as placement of new equipment. For instance:

From a networking perspective, bandwidth and speed will provide greater accessibility.

From a mass storage perspective, distance restrictions for direct attach peripherals will be eliminated, therefore file servers for mass storage can be avoided.

I/O slot utilization can be maximized using a Fibre Channel switch or multiplexer as an intermediate device. Instead of attaching each peripheral or host directly to an I/O slot, it can be attached to the intermediary which itself takes up only one slot.

The ability of Fibre Channel to "package" other protocols can protect existing investment in networking software and SCSI and other devices.

On-going Operations

Once a facility is set up for Fibre Channel, the result should be simplified operations. One of the biggest advantages of Fibre Channel is that it eliminates the need to manage multiple channels and networks. No protocol or software conversion is necessary. New software applications can be developed independently of their use over Fibre Channel. Drivers and diagnostics can be updated the same way as those currently in use for SCSI devices and other hardware.

Why is Hewlett-Packard Committed to Fibre Channel?[6]

Today's competitive marketplace requires businesses to continually evaluate operational procedures as well as products and services provided to the customer. This emphasis on competitiveness demands that information is utilized and managed effectively. Information must be transmitted quickly, regardless of the format, and must be available any time it is requested. To assist in meeting these objectives, Hewlett-Packard is providing Fibre Channel solutions that meet the growing communication needs of businesses.

Fibre Channel provides gigabit level performance for both channel and network protocols, presenting a major shift in the current LAN paradigm by consolidating the channel and network interfaces, in turn providing HP customers with the following benefits:

- Consolidates the network and channel interfaces; fewer I/O backplane slots are used.
- Provides a significant performance improvement over channel interfaces like SCSI, IPI, and ESCON, as well as a performance improvement over network technologies like 802.3, 802.5 and FDDI.
- Supports distances of up to 10 kilometers and may be used on top of single mode fiber, multi-mode fiber or copper.
- Eliminates the need for using a File Server to access mass storage.
- Operates on top of a switched instead of a shared medium, allowing each user to take advantage of the full bandwidth.
- Provides the data integrity and reliability that is typically associated with a channel.

Fibre Channel's unique features make it an ideal technology for scientific computing, clustering and areas where engineering applications are being used involving simulation, collaboration and visualization. This is largely facilitated by the integration of mass storage onto the network interface. Fibre Channel will also be used effectively in those environments where offline decision support is critical, such as in the financial services industry, where customers regularly require large volumes of data to be stored and accessed.

Hewlett-Packard anticipates that Fibre Channel will effectively eliminate the communications bottleneck, eliminating a current problem while enabling future data intensive applications used by business, government and academic institutions. Fibre Channel will enable the clustering of workstations and will provide a high speed link to large storage systems at significantly lower costs than today.

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[6]Hewlett-Packard Company, Corporate Public Relations Backgrounder 1994.

Fibre Channel Topologies

POINT-TO-POINT
- Direct connection between exactly two ports (N_Ports)
- Default topology

ARBITRATED LOOP
- Up to 126 devices in a loop configuration
- Low cost; no hubs or switches needed
- Loops can be connected to fabrics
- Arbitration manages access

FABRIC (Cross-Point Switched)
- One or more switching elements
- Looks like point-to-point to nodes attached to switch (F_Port)
- Up to 16,000,000 nodes

Laser Types and Speeds

Fiber Type	Light Source	Distance (km)	Speed (Mbits/sec)	Data Rate (Mbytes/sec)
Single Mode	Long Wave Laser	10	1062.5	100
		10	531.2	50
		10	265.6	25
Multi-Mode, 50 micrometer	Short Wave Laser	.5	1062.5	100
		1.5	531.2	50
		2.0	265.6	25
	Long Wave LED	2.0	265.6	25
Multi-Mode, 62.5 micrometer	Short Wave Laser	.175	1062.5	100
		.350	531.2	50
		.700	265.6	25
	Long Wave LED	1.5	265.6	25

Mapping, Framing and Transport

Fibre Channel is structured as a set of five hierarchical functional levels. Its application can be compared to addressing, packaging and delivery of a letter:

Upper Level Protocol:
Data is packaged according to protocol of choice, and addressed to destination file name.

FC-4: Upper Level Protocol Mapping Level

FC-3: Common Services
This level is still being defined. Futures include services against multiple ports such as hunt groups, multicast.

FC-2: Framing Protocol

FRAME: A unit of information transfer. Up to 2112 bytes of data.
SEQUENCE: A series of frames
EXCHANGE: A series of sequences

FC-1: Encode/Decode

Defines the transmission protocol: 8B/10B encode/decode scheme, byte synchronization scheme, character-level error detection.

FC-0: Physical Layer

Defines physical characteristics of the media: cables, connectors, drivers, laser type and speed