

Introduction to Fibre Channel and High-Speed Data Communications

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Fibre Channel is a connection technology — it is a high-speed serial interconnect system with the combined features of an integrated channel and network. Fibre Channel supports direct connections, switched connections, loop connections and several classes of data delivery. This is a single technology with applications in networking, disk storage arrays, real-time processing, and much more.

Introduction

This note is to describe the basic terms used in the Fibre Channel definition within the context of modern, well known computers and networks. The principal terms: serial, channel, network, direct, switched, loop, and classes differentiate Fibre Channel and highlight its importance and relevance in next generation computer systems and networks.

Connection, Networking, and Data Transfer

The backbone of all computer systems, wide area and local area networks, network workgroups and clusters, and multiple CPU systems is data transfer. In a simple system, data is transferred between the CPU and system memory, between the system disk and memory, and between input/output components and the CPU. Networked systems have the added necessity of moving data between individual systems and perhaps between systems and shared mass storage devices. Although there are a variety of factors that determine overall system performance, data transfer¹ is clearly one of the most important parameters [1,2].

Connection Systems

There are, in general, two kinds of data connection methods used today: parallel data transfer, and serial data transfer. These interconnect

systems are often called busses and that term will be used throughout this note. Under certain circumstances, a serial interconnect may not be a bus but this will be explained in more detail later.

Parallel Busses

A parallel bus transfers bits of data using 8, 16, 32, or even 64 parallel wires. Each time the bus performs an operation, a large number of bits are all moved simultaneously. For example, a 32 bit bus will transfer four bytes (32 bits) of data on each operation. A bus may perform 33 million operations per second so it transfers 33 million words (or $33 \times 4 = 132$ million bytes) per second. In practice, this sort of bus may require 80 or more parallel wires, it is sensitive to noise, and is often limited to connecting three or four devices.

Serial Busses

A serial bus transfers data by stacking the bits end-to-end to form a bit stream of data. Most serial buses transfer data using four wires; two for transmission, and two for reception but some require additional clock lines increasing the number of wires. Often, these kinds of busses require the inclusion of special bits to keep the system synchronized. This might mean that it takes ten bits to send eight bits of data. Additionally, framing information may also be required to partition the data into regular sized packets or frames. A serial bus might transmit data at 1 billion bits per second for a total of 100 MBytes/s². Serial busses can transmit data in both directions concurrently so the total transfer rate would be 200 MBytes/s.

Connection Methods

There are two principal connection methods used in computers and networks. These two meth-

ods are called multi-dropline busses and point-to-point channels. The bus and channel are both used to move data between devices or systems and there are parallel as well as serial busses. A channel is most often a serial connection but there are some parallel channels.

Multi-Dropline Buses

A multi-dropline parallel bus is what most desktop computers have inside where a number of cards are plugged into and share a single motherboard or backplane. Ethernet and most wide area and local area networks are multi-dropline serial busses. A key characteristic of multi-drop buses is that all components share the resources of the bus. Even though many devices may be connected, only two can transfer data at any one time³. This forces devices on the bus to contend and arbitrate for the resources of the bus which reduces performance and increases communication latencies. The benefit of multi-dropline systems is that they are inexpensive and relatively simple. The drawback is that all components on the bus must compete for and share the data transfer bandwidth of the bus [1,3].

Point-to-Point Channels

A channel is generally defined as a point-to-point link which means there is a single dedicated connection between two devices that have total use and unrestricted access to the connection. A good example of this is a telephone connection between two parties. Once the connection is established, the two parties have direct access to each other and no one else can talk to either party until they hang up (neglecting modern phone features). Channels may be permanently dedicated between two systems, or they may be switched which means different connections can be established and broken. The key is that at any point in time the two connected devices have complete use of the connection. The benefit of point-to-point channels is that devices have a connection path with a guaranteed data bandwidth. The drawback is that any system has a limited number of connection paths.

Transmission Protocols

Common to all parallel or serial multi-drop and point-to-point connections are transmission protocols. Actually there are both hardware and software protocols but it should suffice here to talk

about them as one topic. Most people are familiar with the ISA, EISA, VESA, and PCI transmission protocols found in PC systems. There are also VME, VXI, QBus, MultiBus, SBus, IBus and many other less familiar transmission protocols. TCP/IP, IP, DecNET, and Novel are some transmission standards on serial networks. It is very important to note that the connection medium does not necessarily define the transmission protocol. For example, the same piece of optical fiber might be used to transmit several different and distinct protocols; though not at the same time.

Fibre Channel

Fibre Channel is a transmission protocol using a serial point-to-point connection medium. The connection medium may be copper wire (shielded twisted pair), copper coaxial cable (coax), or optical fiber. Fibre Channel — a transmission protocol — is used to build a connection technology with the features of an integrated channel and network. Fibre Channel connects together “ports” in a variety of topologies⁴ and provides a range of connection services from dedicated to connectionless links. The Fibre Channel Standard (ANSI X3.320-1994) defines a unique physical and signaling interface including advanced protocols (signaling layers) capable of implementing other transmission protocols such as SCSI, Ethernet, and TCP/IP [4,5]. The next few sections briefly highlight some of the features and capabilities of Fibre Channel.

Point-to-Point

Fibre Channel can provide a dedicated channel⁵ between two devices. This connection may be a physical link⁶ or a logical connection through a switch fabric. This sort of channel might be used to connect together high-performance processors, a processor and I/O device, or supercomputers. Connection distances up to 10 Km are supported.

Switches

A Fibre Channel switch is called a fabric. Fabrics are used to connect many individual ports together and to establish channels between two ports. The fabric is responsible for routing frames from one end-point to another so the two connected ports do not need to know routing information only individual addresses which greatly simplifies port de-

sign. A fabric can support all classes of service including Arbitrated Loop connections.

Arbitrated Loop

The Fibre Channel Arbitrated Loop (FC-AL) provides a low-cost means of connecting multiple communication ports together in a loop topology. This connection is done without switches or hubs so each connection is made with minimal hardware. The loop bandwidth is shared among all ports connected and up to 127 ports may participate on each loop. Multiple loops may be interconnected and loops may be connected to fabrics. This topology provides a economical way to build workgroups, clusters, or local area networks of workstations all sharing one fiber or cable. Separate clusters can be interconnected using dedicated links or fabrics to form large distributed computing networks.

Another very important use of Arbitrated Loop technology is in building disk arrays. A large number of disk drives may be attached to one or more loops to form a mass storage system that behaves as one enormous disk drive. The disk system, in turn, is a member of the network and is available to all participating ports.

Summary

Fibre channel behaves as a channel service because it provides dedicated point-to-point links with a guaranteed communication bandwidth. It also functions as a network because nodes can be connected together as a loop or through a fabric and each node may be addressed using a unique port address. The protocol supports unique Fibre Channel frames but is flexible enough to allow other transmission protocols to be encapsulated. This technology provides a combination of great flexibility and expandability with maximum performance at economical prices. A single technology provides the ability to build local area networks, wide area networks, workstation clusters, mass storage systems, and high-performance multiprocessing systems.

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¹ Data transfer rate is the number of Megabytes per second (MBytes/s) transferred between two points. This is also called data transfer bandwidth.

² The typical 8 bit to 10 bit ratio reduces the data rate by 20%

³ Not including broadcast or multi-cast communications

⁴ The logical and/or physical arrangement of stations on a network

⁵ Point-to-point link, the main task of which is to transmit data from one point to another

⁶ Two unidirectional fibers/wires and their associated transmitters and receivers