Frame Switching, Routing, and Delivery Using the FCX40 C40 Fibre Channel Controller

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Fibre Channel Communication

Fibre Channel, a scalable high performance (1.06 gigabit/sec) interconnect standard, provides fast transfer of large volumes of data between devices over relatively long distances. The Fibre Channel Standard (ANSI X3.320) addresses the need for an inexpensive high-speed data transfer mechanism between processors and peripherals [1,2].

The FCX40 Fibre Channel controller can be used to implement a variety of communication systems including native Fibre Channel, Gigabit Ethernet, distributed data acquisition systems, hybrid networks, and others. Since Fibre Channel has been adopted as the serial SCSI interconnect standard, disk and tape storage systems can be connected directly to the Fibre Channel network. These systems might implement standard Fibre Channel FC-3 and FC-4 services, TCP/IP, SCSI-III encapsulation or proprietary protocols using either standard or non-standard data frames.

Basic Concepts

Fibre Channel communications consists of ***exchanges*** between two or more node ports (***N_Ports***) that may be physically connected point-to-point using fiber or copper media or logically connected through a switch fabric. If the connection is through a fabric, two or more fabric ports (***F_Ports***) interconnect the N_Ports. An exchange is composed of one or more unidirectional frame ***sequences*** each being uniquely identified by values, called the exchange ID (X_ID), in each frame header.

A frame is composed of a start-of-frame ordered set, a header, a data payload; an end-of-frame ordered set, and the frame's CRC. (Ordered sets are sometimes called comma detects.) Fibre Channel supports several frame delivery ***classes*** with differing degrees of performance and reliability [3]. Each frame header contains sufficient information to insure data delivery from the sequence initiator to the responder and an acknowledgement back to the initiator in class 1 and 2 connections. Broadcast and multicast sequences are supported by some service classes and part of the payload may include ***optional headers*** that allow encapsulation of other communication standards such as IP or SCSI.

Channel Services

Basic Fibre Channel service connects two (or more) N_Ports together and delivers data from one port interface to another. Each N_Port is composed

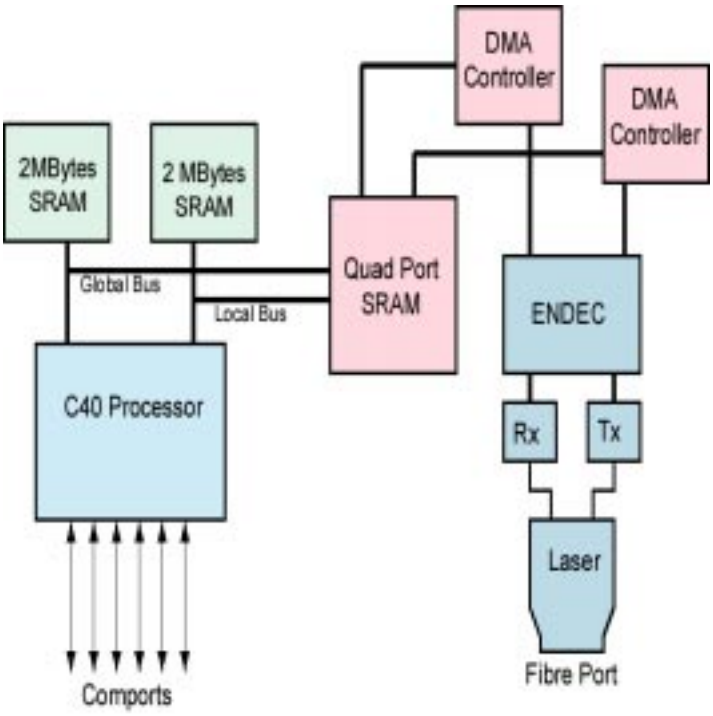


Figure 1. FCX40 Block Diagram

of several ***physical and signaling*** layers that transport data between the upper level protocol (FC-4) and common service layers (FC-3) to the lower level physical transport layers. The ***data interface*** at each port is application specific and may vary widely between systems.

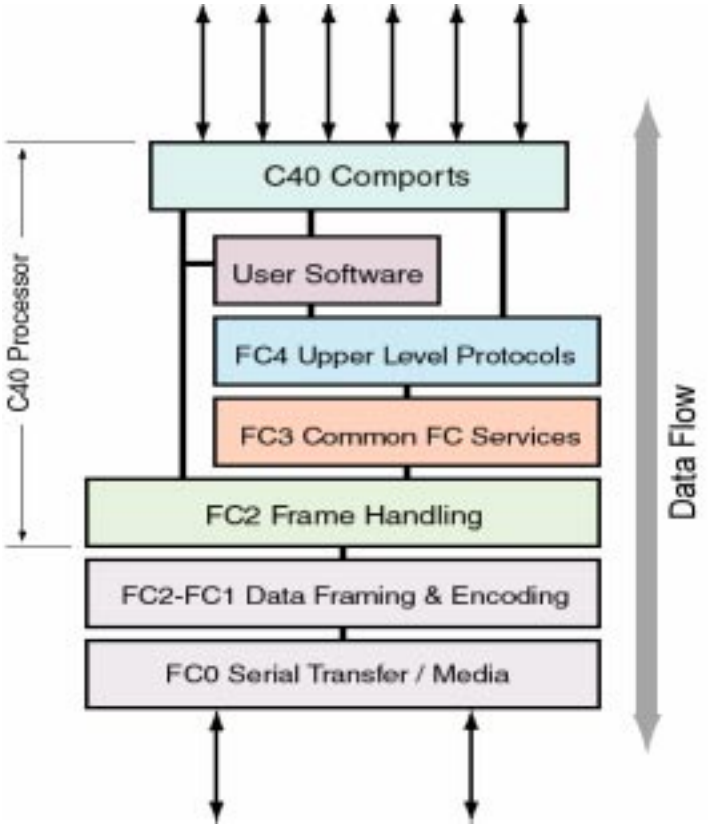


Figure 2. N_Port Signaling Structure

Data Interfaces and C40 Processor

The FCX40 has one 1063 Mbit/s Fiber Channel port and six bidirectional 160 Mbit/s (20 MByte/s) C40 comports. The Fibre Channel port functions as either a N_Port or F_Port depending on the application and configuration software. Each C40 comport functions as 1) a native C40 comport; 2) a Fibre Channel N_Port; or 3) a Fibre Channel F_Port based on configuration software supplied by DSP Systems or the user.

The primary function of the on-board C40 processor is to move data between comports and between comports and the Fiber Channel port. Some C40 processor bandwidth may be available to execute specialized code for data processing or enhanced formatting.

Configuration Options

FCX Systems software includes Extended Fibre Channel Service routines supporting port login processing as specified in FC-PH [4]. Implicit login is supported by a static configuration database and explicit login is supported as specified in FC-PH.

Default Implicit Login

Each port (comport and Fibre Channel port) is initialized at power-up and reset to a particular mode specified in the implicit login database. The Fibre Channel port initializes as a F_Port and begins initiating F_Port login procedures shortly after reset. The C40 comports initialize as N_Ports and begin N_Port login procedures after reset. This configuration produces a simple switch fabric using all FCX40 found during login.

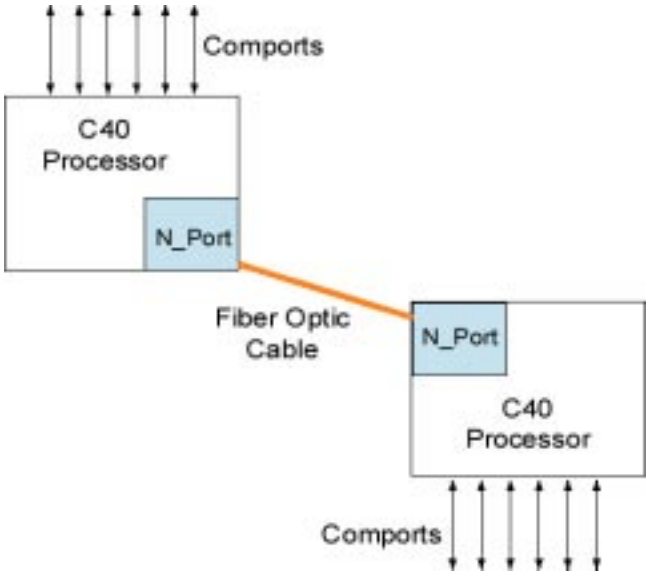


Figure 3. Native Mode Virtual Comport Connection

Explicit Login

Default port configurations can be overridden by explicitly logging into an FCX40 port using different login parameters. Login involves requesting connection to a specific type of port with a specific connection class (1-5). If the configuration and class are supported, on that port, and acknowledgement frame is returned from the port. Once login is completed, no other control functions are required and data transmission may begin.

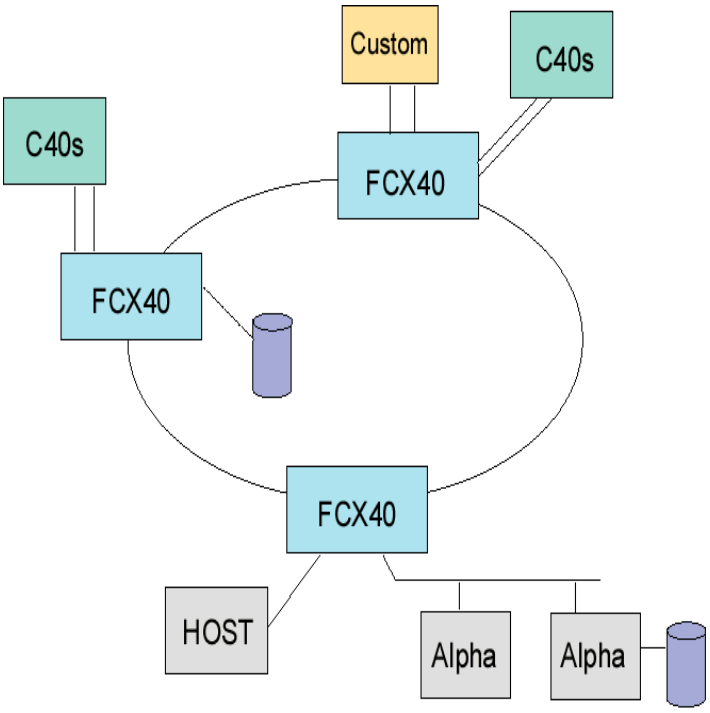


Figure 4. Fibre Channel Network

C40 Comport Configurations

C40 comports can be configured to operate in several different modes to handle standard C40 data transfer and Fibre Channel F_Port or N_Port services.

Native Comport Mode

Native mode comports function as any other C40 comport and can be interconnected to C40 networks supporting DSP Systems or native comport interfaces. These comport function as virtual links that transfer data between two ports connected over Fibre Channel. Figure 3 is an example of native comports connections. Port source and destination routing is programmed through implicit or explicit login and the local FCX40 C40 processor will normally not be visible to network “worm” programs. This basic configuration can be enhanced or modified with user supplied software.

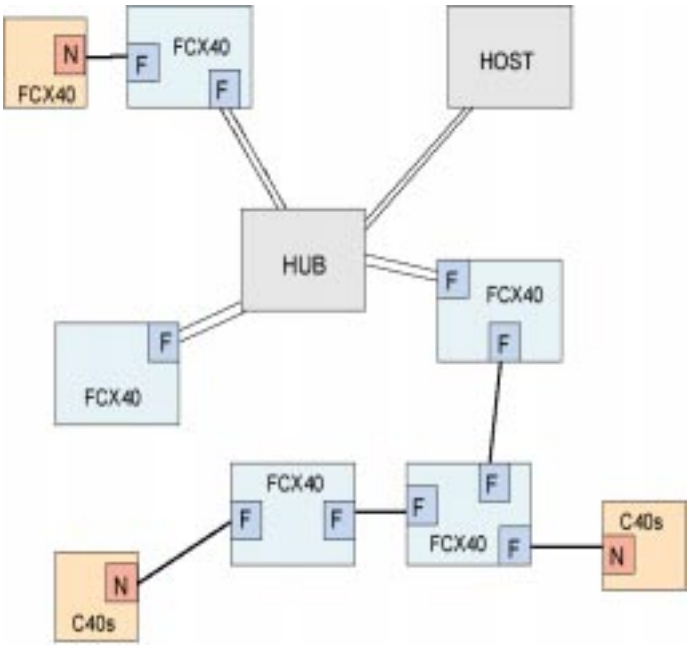
N_Port and F_Port Modes

N_Ports; the source and destination of all data frames — within a Fibre Channel system — each have a unique system wide identifier. N_Ports may be connected through a switch fabric using F_Ports producing subnets and networks.

Communication software allows one or more of the C40 comports to behave as a N_Port, but not all comports are required to support Fibre Channel communication. Therefore, a C40 node is the bridge between Fiber Channel communications and native C40 communications. For example, figures 3 and 4 show C40 nodes connected to a Fibre Channel network system using one or more comports each. This leaves the remaining comports for native communications.

F_Ports are entry points to Fibre Channel switch fabrics. A fabric establishes connections between N_Ports that are not directly connected to each other. A fabric may provide several classes of connections (see definitions below) that establish direct point-to-point channels or frame switched or connectionless network connections.

Other C40s, connected to the FCX40 comports emulating N_Ports or F_Ports use supplied software libraries to login to an FCX40 port and to send and receive Fibre Channel frames between C40 nodes. These routines use only a portion of processor resources leaving the balance for user applications.



Figue 5. Fibre Channel Network

Frame and Message Format

Standard Fibre Channel frames support data payloads ranging from 128 to 2112 bytes. The FCX40 supports payload sizes from 12 to 8180 bytes. Frame headers may be pre-constructed and

cast into quad ported memory then used, as data becomes available. During data transfer in an open exchange only a few header values change so most of the frame header can be reused.

Distributed Software Tools

Fibre Channel Systems and Active Parallel Instrumentation are developing software for the FCX40 and C40 processors that implements the N_Port and F_Port Link Control Facility, and Common Service Layer of the Fibre Channel specification. This software supports TCP/IP encapsulation and could be enhanced to support SCSI command encapsulation.

This means that networks of front-end C40 processors designed for high-speed signal processing can be combined with back-end workstations running a standard operating system with sophisticated analysis tools. For example, an Intel or DEC Alpha workstation — with a PCI interface — running Windows NT can be connected to a network of C40 processors using an FCX40 running IP encapsulation software. Such a system would support most data exchange features of Windows NT such as:

- Dynamic Data Exchange
- Object Linking and Embedding
- Open Database Connectivity
- Structured Query Language

This means that multiple Windows NT workstations can configure and control an array of C40 processors performing data acquisition and signal processing. Each Workstation and some C40s would have access to shared data structures used for experimental control and data handling.

Summary

Sophisticated and powerful networked data systems can be easily constructed using the FCX40, C40 hardware and Windows NT workstations. These systems support object linking, shared databases, and SQL — served by host workstations — which allows Workgroups to setup and control remote and distributed data systems.

It is, however, just as easy to construct simple distributed data acquisition and signal processing systems using the FCX40 and C40 processing hardware. The FCX40 functions, in this case, as a virtual connection linking distributed C40 hardware into a single unit. Standard DSP programming tools are supported making software development identical to programming a few processors in a PC host system.

References

1. “Introduction to Fibre Channel and High-Speed Data Communications”, DSP Systems, (1996) …/ftp/fcintro-app.pdf

2. “Fibre Channel — the Standard for Moder Computer Connection Systems”, DSP Systems, (1996) …/ftp/fccomms-app.pdf

3. “Gigabit Serial Links Using Fibre Channel Technology”, DSP Systems, (1995) …/ftp/gblinks-app.pdf

4. Fibre Channel Physical and Signaling Interface. Ed. ANSI X3.230-1994. Available from Global Engineering (1996).

References are available at www.dspsystems.com/ftp/<filename>

Definitions and Conventions

Arbitrated Loop: A configuration that allows multiple ports to be connected serially in a loop topology.

Class 1 Service (circuit switched): A service, which establishes a dedicated point-to-point connection between communicating N_Ports.

Class 2 Service (frame switched): A service which multiplexes frames, at frame boundaries, to or from one or more N_Ports with acknowledgement provided.

Class 3 Service (connectionless): A service which multiplexes frames, at frame boundaries, to or from one or more N_Ports without acknowledgement provided.

Class 4 Service (guaranteed fractional bandwidth): A service that divides a connection into 256 subgroups each having non-blocking continuous service.

Class 5 Service (Isochronous): A service that provides frame delivery based on a fixed time base.

Connection DataBase: The database that describes a network topology and the path to each attached N_Port.

Fabric: The entity which interconnects various Ports attached to it and is capable of routing frames by using only the X_ID information in the FC-2 Frame header.

F_Port: The Link Control Facility within the Fabric which attaches to an N_Port, C40 comport, or another F_Port† through a link.

Fabric Controller: The processor that implements a Link Control Facility for one or more F_Ports in a Fabric. The Fabric controller establishes and manages different classes of connections through a Fabric based on a connection data base and connection requests.

L_Port: An N_Port or F_Port capable of executing Arbitrated Loop functions associated with Arbitrated Loop topology.

Native C40 comport: Is a standard 8-bit parallel C40 comport using STRB / RDY as data handshake signals and REQ / ACK as data direction signals.

Network: A connection between F_Ports that is addressable without using a bridge, router, or switch and does not traverse a Fabric Link Control Facility.

Node: A device located at an *edge* of a network containing one or more N_Ports that is the originator or responder to Fibre Channel frames and does not perform routing or switching functions. A node may use C40 comports to route or transfer messages apart from the Fibre Channel network topology.

N_Port: A hardware entity which includes a Link Control Facility and may act as an frame originator, responder, or both.

N_Port Controller: The processor that implements the Link Control Facility for one or more N_Ports.

Port: A generic reference to a N_Port, F_Port, or C40 comport† (C_Port).

Sub-Network (subnet): A connection between F_Ports establish within a Fabric Link Control Facility.

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† This document extends the FC-PH specification to allow F_Port to F_Port connections and to include C40 comports in the definition of N_Port (Port).

This note is available as www.dspsystems.com/ftp/frame-xfer.pdf

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