Gigabit Networking Standards: Fibre Channel and HIPPI

Raj Jain

Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
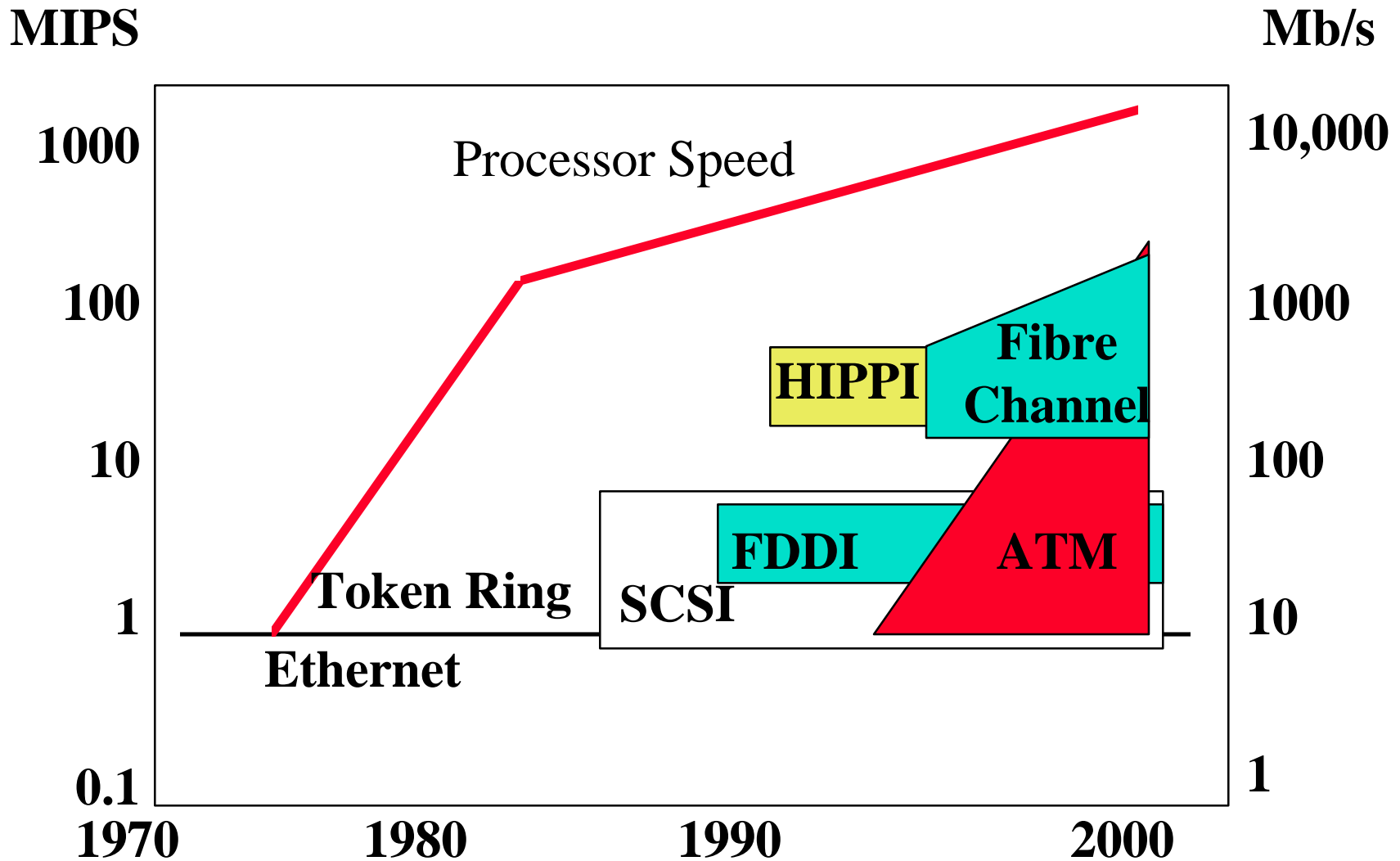http://www.cse.wustl.edu/~jain/

Overview

- ❑ Who needs a gigabit?

- ❑ HIPPI
    - ❑ Architecture
    - ❑ Products

- ❑ Fibre Channel
    - ❑ Architecture
    - ❑ Products

Gigabits - Who Needs it?

- Amdahl's Law: One bit I/O per instruction
- Mb/s = MIPS
- 100 MIPS machine needs 100 Mb/s I/O
- 1000 MIPS machine needs 1000 Mb/s I/O
- 133 MHz Pentium = 200 SPECint92 = 200 MIPS
- 200 MHz Pentium Pro = 350 SPECint92
- Quad-Pro system = 1400 MIPS on your desktop
- SCSI = 5-20 MBytes/sec = 80-160 Mb/s

Communications Bottleneck

MIPS

Mb/s

Processor Speed

1000 — 10,000

100 — 1000

Fibre Channel

HIPPI

10 — 100

FDDI

ATM

SCSI

1 — 10

Token Ring

Ethernet

0.1 — 1

1970   1980   1990   2000

Raj Jain

HIPPI

- High Performance Peripheral Interface
- Los Alamos National Lab needed to connect displays with supercomputers
- 1k × 1k pixel × 24 bits/pixel × 30 frames/s = 750 Mb/s
- Proposed in January 1987
- Standard in 1991
- Fiber was too expensive ⇒ Copper ⇒ 25 Mb/s
- Copper ⇒ 25 Mb/s ⇒ 800/25 = 32 pairs

HIPPI Overview

- ANSI standard

- Speeds: 800 Mb/s and 1.6 Gb/s

- Cabling: 50-pair STP
  Recently extended to single-mode and multimode fiber

- Distance: 50 meters point to point over copper.
  200 meters over copper w cascaded switches
  300 meters over multimode fiber
  10 kilometers over single-mode fiber

- Point-to-point link. Simplex (one-way) connection

- Cost per switched port: $2,000

- Cost per adapter card: $2,000 to $18,000

Framing

Burst — 256 Words

Frame
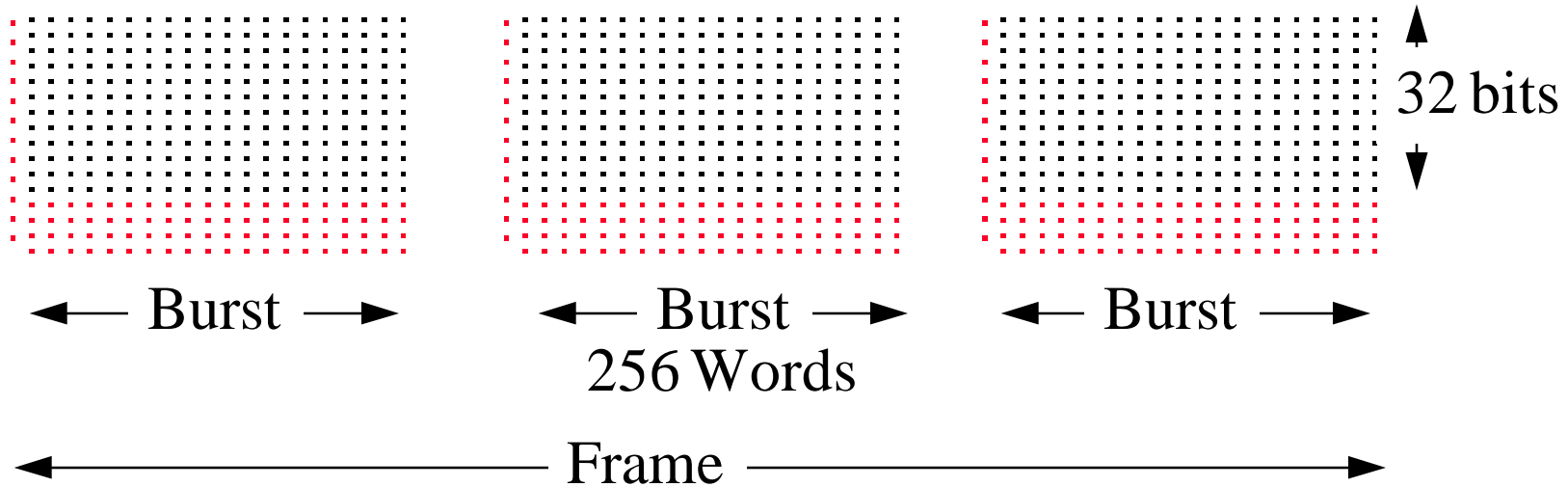
- Burst = 256 words
- 4 parity lines/word
- Longitudinal parity
- No CRC
- 64-bit CRC was not accepted

HIPPI Products

- **HIPPI Switches**: Avaika Networks, Essential Communications, NetStar Inc., Network System Corp.

- **HIPPI routers and bridges**: NetStar Inc. Gigarouter,

- **Host Interface Adapters for HIPPI**: Avaika Networks, Cray Research, Essential Communications, IBM's MCA HIPPI adapter for the RS/6000 and SP2, Myriad Logic, Network System Corp., Silicon Graphics

- **HIPPI storage devices**: Maximum Strategy, TRW, TRIPLEX

HIPPI Products (Cont)

❑ **HIPPI Frame Buffers**: Avaika Networks, PsiTech,

❑ **HIPPI extenders**: Broadband Communications Products, Network Systems Corp.

❑ **HIPPI analyzers and tools**: Avaika Networks, Essential Communications

❑ **HIPPI components**: AMCC, BCP, Methode

CERN is using HIPPI for data collection from a Large Hadron Collider

Fibre Channel: Overview

- The name is a misnomer
    - Runs on copper also
    - Fibre channel is a Channel-network hybrid
    - Simplicity, reliability, hardware implementation like a channel
    - Connectivity, distance, serial interface like a network
- 12.5, 25, 50, and 100 MByte/s
  Extended to 2 and 4 Gb/s (March 1995)
- 10 km or less per link
- Small connectors
- Multidrop (126 devices) possible

Overview (Cont)

❑ Multiple cost/performance levels
$\Rightarrow$ Personal computers to supercomputers Full duplex (simultaneous bi-directional) communication

❑ Uses IBM's 8b/10b code $\Rightarrow$ 12.5 MByte/s
= 100 Million data bits/s = 125 Million code bits/s
= 132.8125 Mb/s on the media

❑ Variable length frames

❑ Provides many existing interface command sets:
SCSI, IPI, HIPPI, IP, IEEE 802, ATM
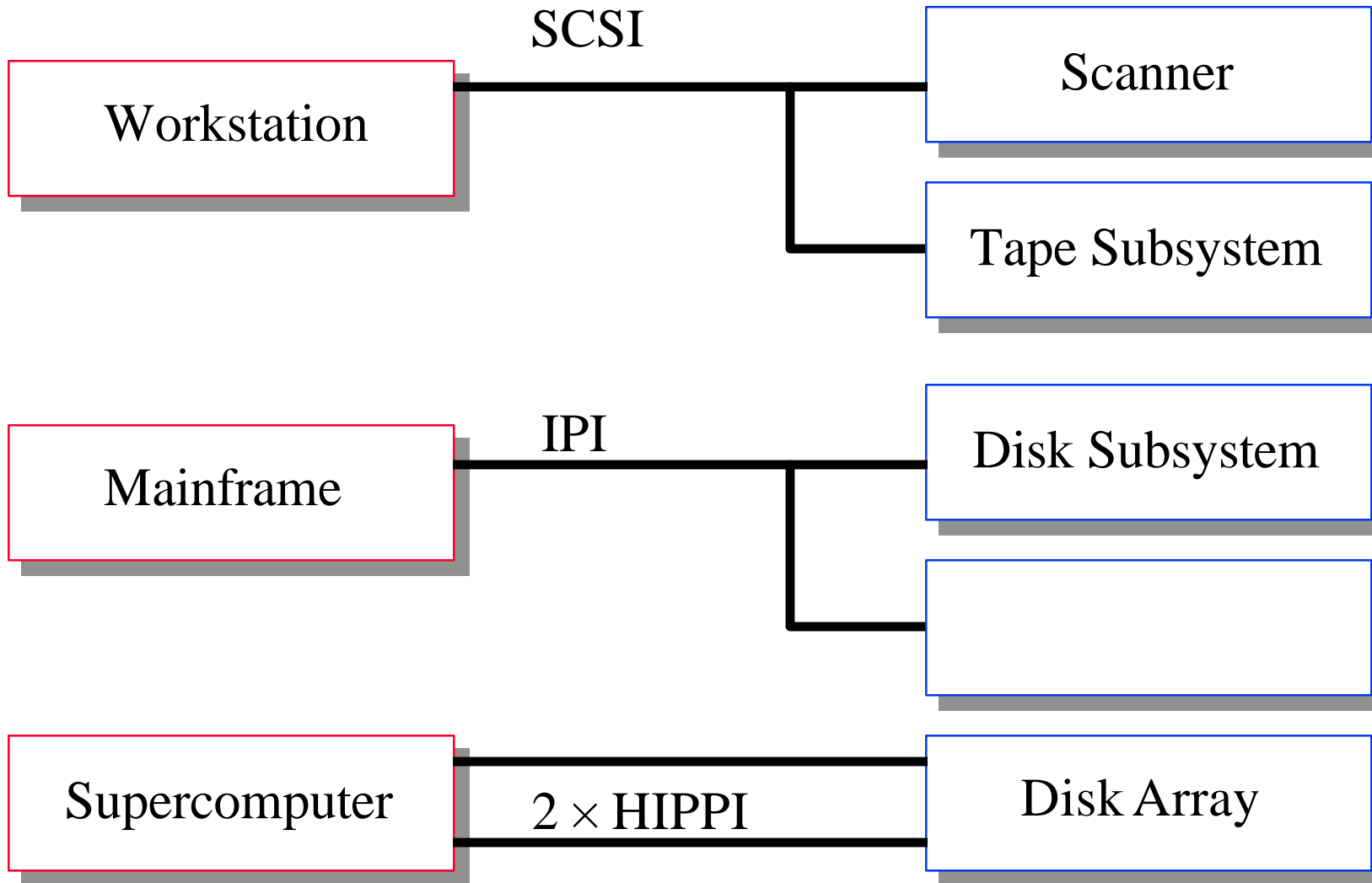$\Rightarrow$ You can use current driver software 16 Million nodes per fabric

History

- Began as a part of IPI enhanced physical
- 1988: Chartered by X3T9 in 1988
- Sept 1989: Picked IBM's High-Speed Interconnect
  (over ANCOR Fast Net, Canstar Hubnet, DG Fiber-ICB,
  ICL MacroLan, HP-FL)
- Oct 1989: Picked IBM's 8b/10b
  (over 4b/5b, DEC 8b/10b, HP 16b/20b)
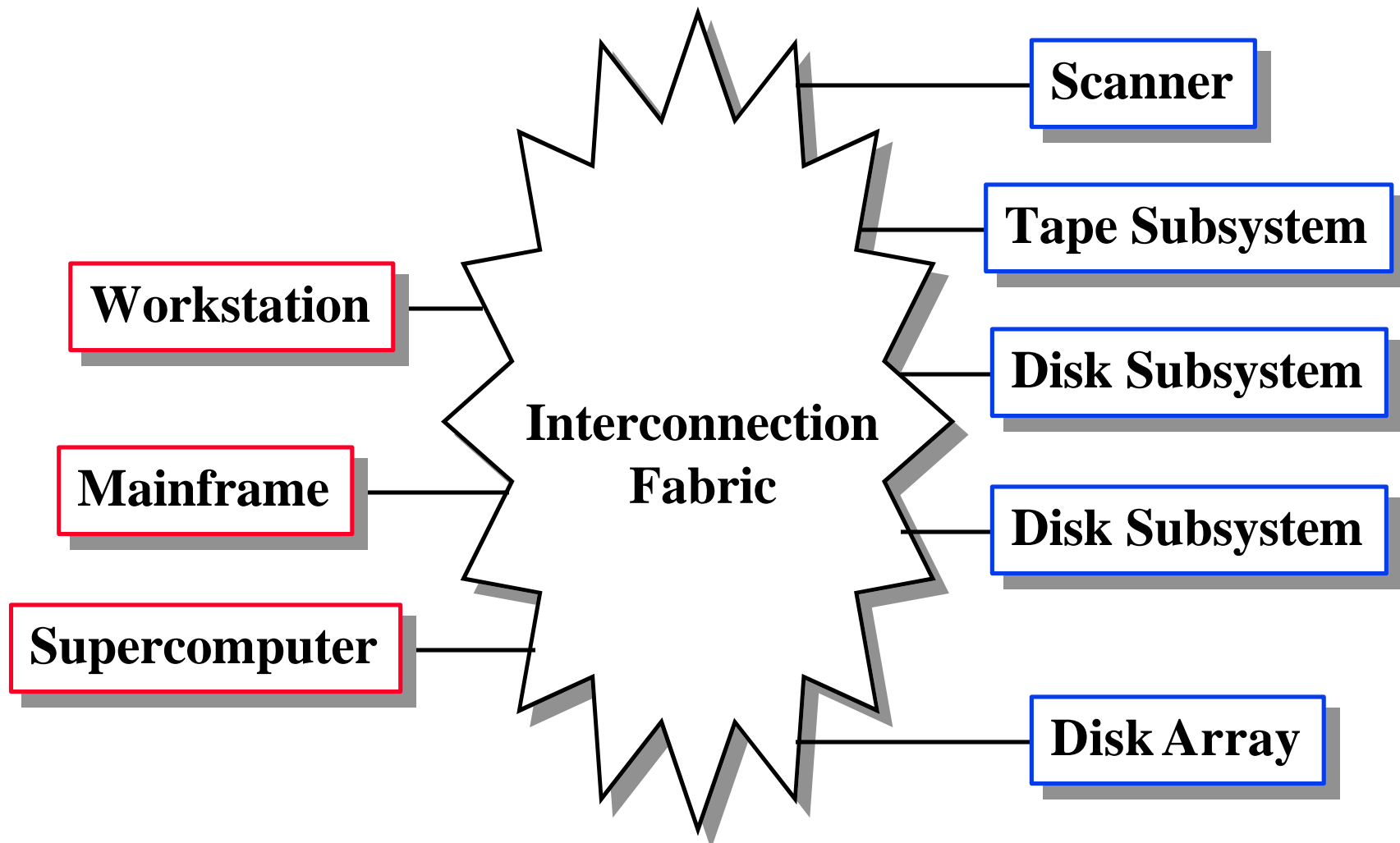- August 1991: Physical layer forwarded for peer review
- 1994: FC-PH ANSI Standard

Fibre Channel Applications

- High performance workstations
- Disk drives, tape units, graphics terminals, laser printers, optical storage devices
- Heterogeneous workstation clustering
- Campus-wide Distributed Computing
- Medical centers can share X-Rays and MRIs
- Backup Data centers at safe/secure distance
- Printers linked to a LAN without a CPU
- Disk drives linked to a LAN without a CPU

Existing Channel Architectures

SCSI

Workstation ———————— Scanner

Tape Subsystem

IPI

Mainframe ———————— Disk Subsystem

Supercomputer —— 2 × HIPPI —— Disk Array

Fibre Channel Architecture

Scanner

Tape Subsystem

Workstation

Disk Subsystem

Interconnection Fabric

Mainframe

Disk Subsystem

Supercomputer

Disk Array

Protocol Layers

	Channels					Networks		

FC-4	**IPI**	**HIPPI**	**SCSI**	**SBCCS**		**802.2**	**IP**	**ATM**

FC-3	**Common Services (being defined)**

FC-2	**Framing /Flow Control/Signaling**

FC-1	**Encode/Decode (8b/10b)**

FC-0	**133MBaud**	**266MBaud**	**531MBaud**	**1.062 GBaud**	**2.124 GBaud**	**4.248 GBaud**

Media: Copper - Coax, Twisted Pair
Optical - Laser, LED

Raj Jain

Media Type

❑ All popular media: Fiber and Copper

❑ Different distances and speeds

Medium	MBps	Distance	MBaud	Source
9-μm SM Fiber	100	10 km	1062.50	Longwave Laser
	50	10 km	531.25	Longwave Laser
	25	10 km	265.62	Longwave Laser
50-μm MM Fiber	50	1 km	531.25	Short-wave Laser
	25	2 km	265.62	Short-wave Laser
62.5-μm MM Fiber	25	500 m	265.62	Longwave LED
	12.5	1 km	265.62	Longwave LED

Media (Cont)

Medium	MBps	Distance	MBaud
Video Coax	100	25 m	1062.50
	50	50 m	531.25
	25	75 m	265.62
	12.5	100 m	132.81
Miniature Coax	100	10 m	1062.5
	50	20 m	531.25
	25	30 m	265.62
	12.5	40 m	132.81
Shielded Twisted Pair	25	50 m	265.62
	12.5	100 m	132.81

# Framing and Signalling : FC-2

❑ Framing Structure

❑ Variable length frames up to 2k + 64 bytes user data

❑ 32-bit Cyclic Redundancy Check (CRC)

Start of Frame	Frame Header	Optional Header	Payload	CRC	End of Frame
4	24	64	0-2048	4	4

Size in Bytes
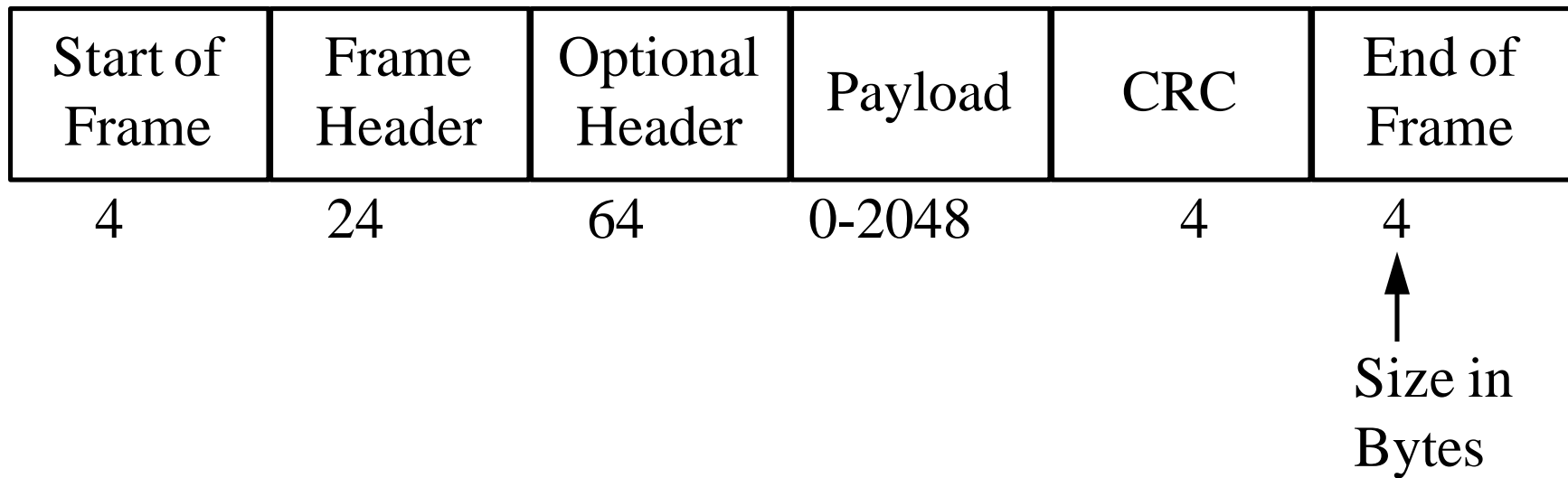
Sequences and Exchanges

❑ Sequence = Group of frames flowing in the same direction

❑ Exchange = Group of sequences for a single operation

Raj Jain
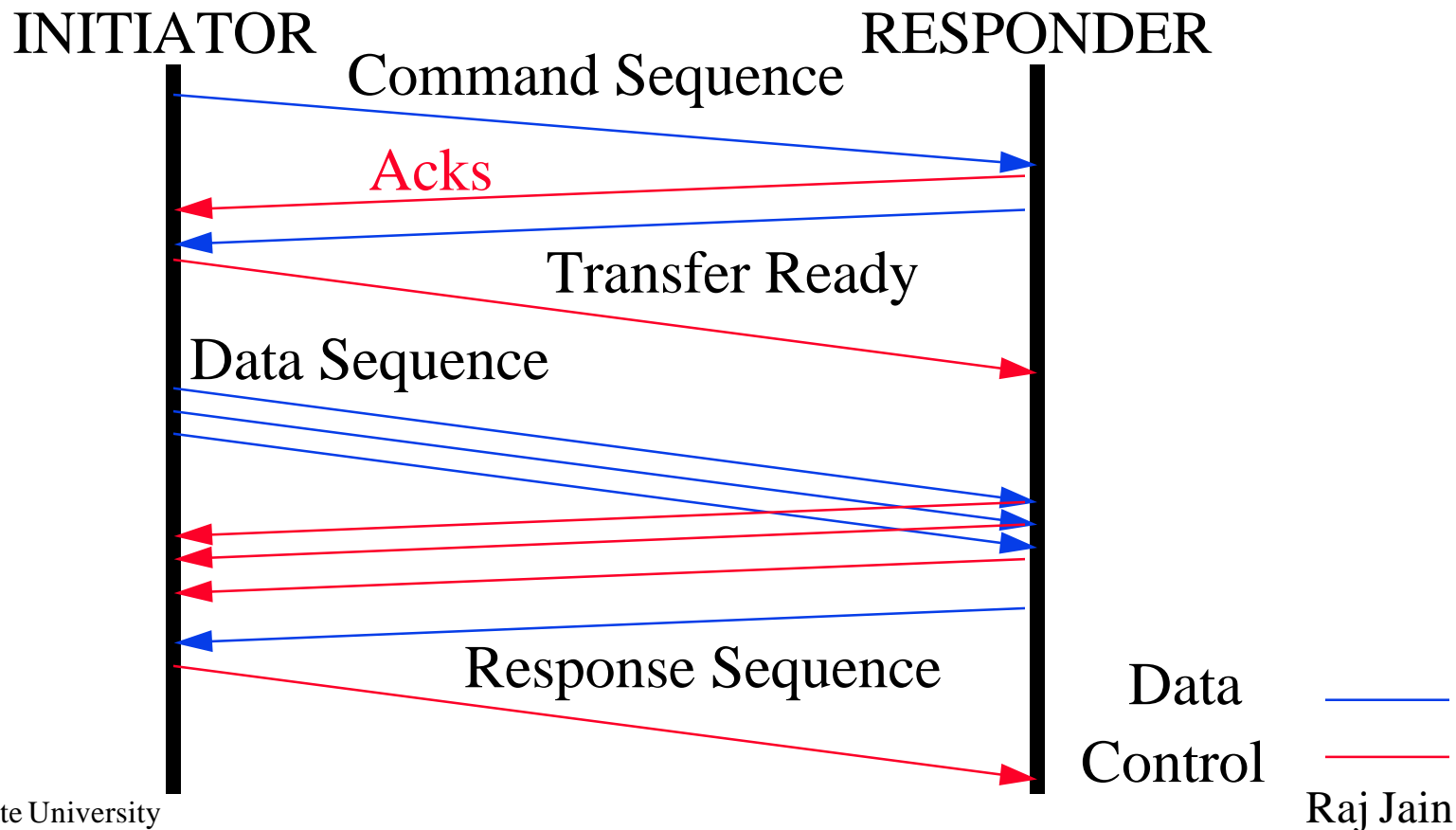
FC-4: Upper Layer Protocols

- **SCSI**: Small Computer System Interface
- **IPI**: Intelligent Peripheral Interface
- **HIPPI**: High Performance Parallel Interface
- **IP**: Internet Protocol
- **AAL5**: ATM Adaptation Layer
- **FC-LE**: Link Encapsulation
- **SBCCS**: Single Byte Command Code Set Mapping
- **IEEE 802.2**

Fabrics

❑ Provide parallel transmissions (rather than media sharing of LANs)

❑ Extend the distance supported

❑ Limited to 2^{24} addresses (16 million)

❑ Relieve nodes from routing issues

❑ Nodes simply "call" the destination and set up a connection (Class 1)
Or put the responders address on the frame (Class 2)

❑ Originator gets a busy signal if not delivered

❑ Connect devices that run at different speeds

❑ Provide cable matching

Types of Ports

- ❏ N_Port: Node Port
- ❏ F_Port: Fabric Port
- ❏ L_Port: Loop Port (needs a FL_Port on a switch)
- ❏ NL_Port: Node + Loop port (Does not need a fabric)

N ——— N

Switch

N   N   L   L   NL   NL
  F F   F   F
  F F   F   F
N   N   L   L   NL   NL
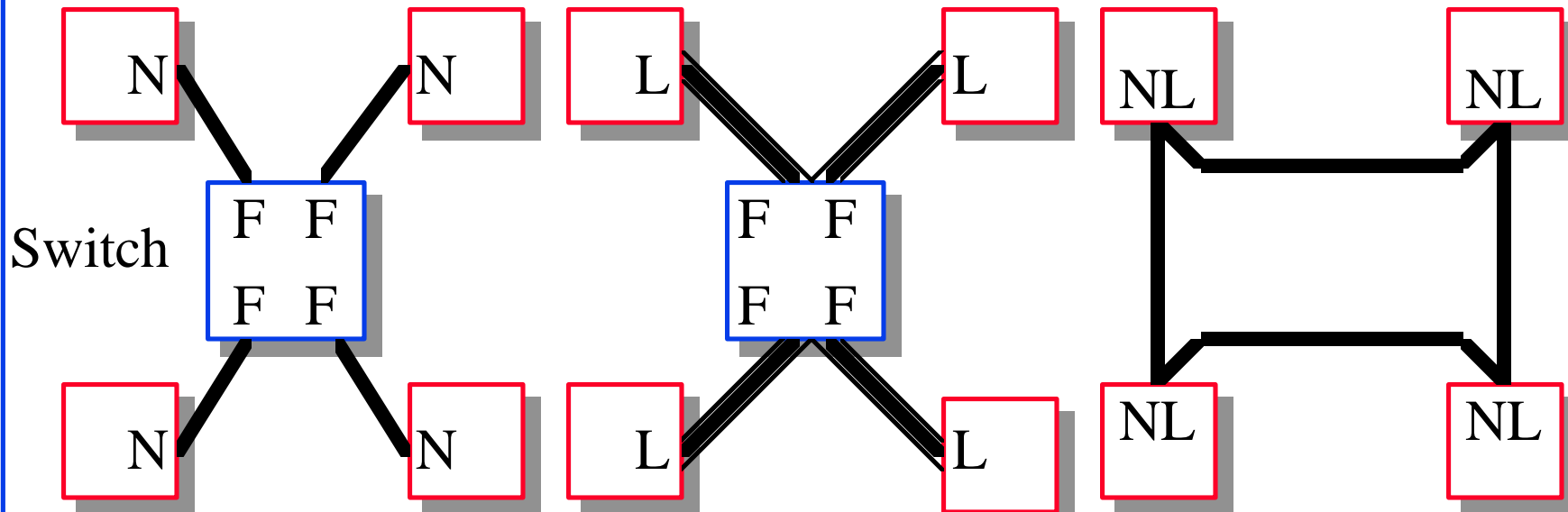
Arbitrated Loop

❏ Storage interconnection

❏ Interconnection of small numbers of devices

❏ Intermittent high bandwidth situations

❏ Generally limit to 30 nodes and 100 m

File Server

Disk Subsystem

NL

NL

NL

NL
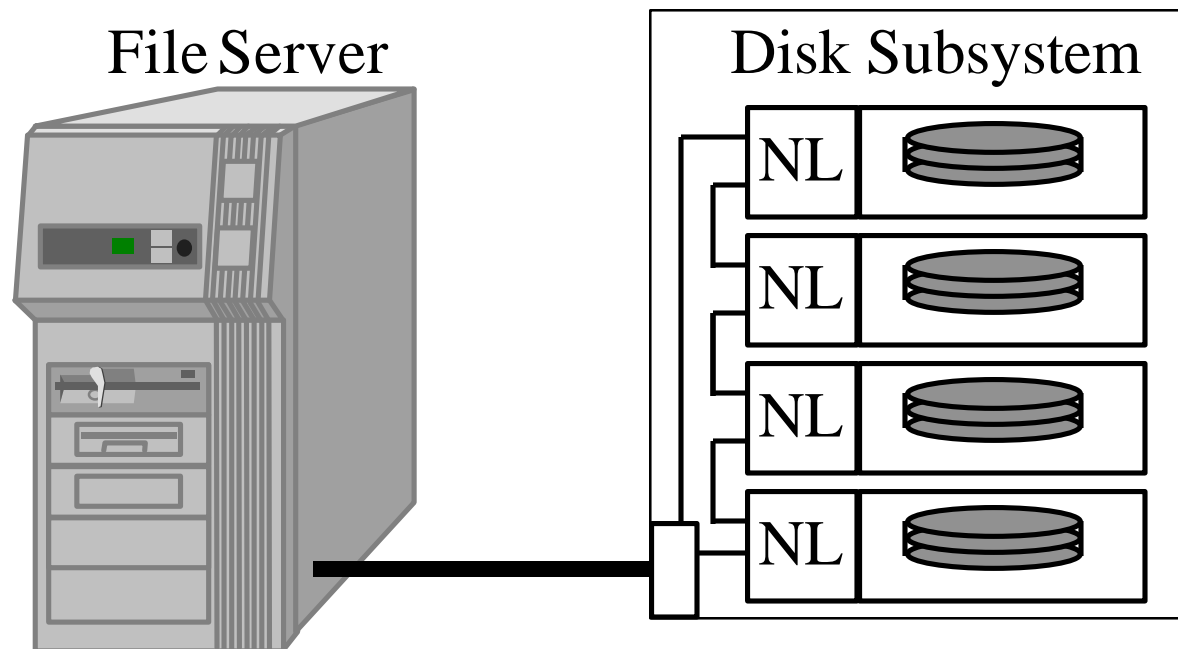
Classes of Service

❑ Class 1: Dedicated connections. Guaranteed bandwidth.
Frames delivered in order

❑ Class 2: Frame-switched, connection-less service.
Bandwidth shared by frame multiplexing.
Frames may be delivered out of order.
Guaranteed delivery (Acks and retransmissions).

❑ Class 3: Datagram service. Send and Pray.
Neither order nor delivery is guaranteed.

❑ Intermix = Class 1 and 2

Class 1   Class 2
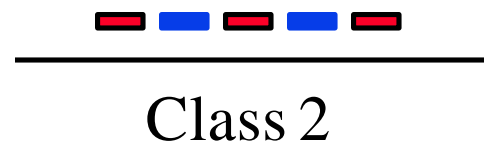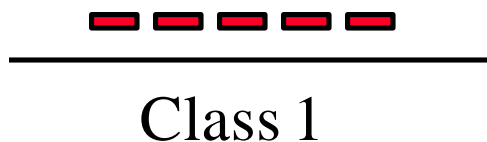
Future Directions

❏ Higher bit rates

❏ Unshielded Twisted Pair

❏ Wavelength division multiplexing

❏ Hunt Groups

❏ Multicast groups

❏ Class 4: Fractional bandwidths.
   Multiple VC's of different QoS share the link

❏ Simplex Class 1: Unidirectional

❏ Buffered Class 1: Communication between different data-rate nodes through a fabric

❏ Lossless Data Compression

Fibre Channel Products

❑ Components (Chips, cables, etc.)

❑ Fabrics

❑ HIPPI converters

❑ Interfaces

❑ Routers (Ethernet, FDDI, Token Ring, ATM)

❑ SCSI converters

❑ Software and Services

❑ Storage devices

❑ Testers

Summary
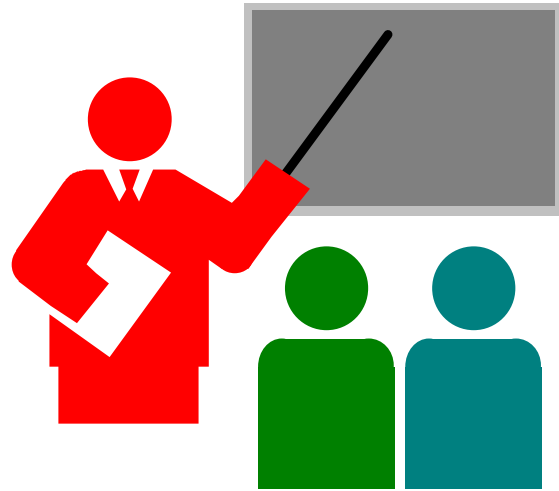
- 800 Mb/s over 10s of km between millions of nodes
- Point-to-point, loop, switched fabrics
- 12.5, 25, 50, 100 MB/s
- SCSI, IPI, HIPPI, LAN card replacement

HIPPI References: On-Line

❏ The HIPPI Protocol,
http://www.cis.ohio-state.edu/~jain/cis788/hippi/

❏ The HIPPI Networking Forum,
http://www.esscom.com/hnf/index.html

❏ Links to other HIPPI pages on the web,
http://www.esscom.com/hnf/html/links.html

HIPPI References: Standards

❑ ANSI X3.183-1991, "High-Performance Parallel Interface - Mechanical, Electrical, and Signaling Protocol Specification (HIPPI-PH)"

❑ ANSI X3.210-1992, "High-Performance Parallel Interface - Framing Protocol (HIPPI-FP)"

❑ ANSI X3.218-1993, "High-Performance Parallel Interface - Encapsulation of ISO 8802-2 (IEEE Std 802.2), Logical Link Protocol Specification (HIPPI-LE)"

❑ ANSI X3.222-1993, "High-Performance Parallel Interface - Physical Switch Control Specification (HIPPI-SC)"

Related Standards & RFC's

- ANSI/ISO 9318-3:1990, "Intelligent Peripheral Interface - Device Generic Command Set for Magnetic and Optical Disk Drives (IPI-3 Disk)"

- ANSI/ISO 9318-4:1990, "Intelligent Peripheral Interface - Device Generic Command Set for Magnetic Tape Drives (IPI-3 Tape)"

- IEEE 802.2, "Link Encapsulation" (also known as ISO 8802-2, "Logical Link Protocol Data Units")

- "Serial-HIPPI Specification, Revision 1.0, Serial-HIPPI Implementers Group"
  ftp://nsco.network.com/hippi/serial_hippi_1.0.ps
  (but this site & file were not found.)

- IETF RFC 1374, "IP and ARP on HIPPI"

HIPPI References: Papers

- D. Tolmie and J. Renwick, "HIPPI: Simplicity Yields Success", IEEE Network, Vol. 7 No. 1, January 1993, p. 28-32.

- D. Tolmie, "High-Performance Parallel Interface (HIPPI)", in "High Performance Networks, Technology and Protocols," edited by Tantawy, Kluwer Academic Publishers, 1994.

- J. P. Hughes, W. R. Franta, "Geographic extension of HIPPI channels via high speed SONET", IEEE Network, Vol. 8 No. 3, May-June 1994. p. 42-53.

- I. Chlamtac, A. Ganz, M. G. Kienzle, "An HIPPI Interconnection System", IEEE Transactions on Computers, Vol. 42 No. 2, Feb 1993. p 138-150.

- I. Chlamtac, M. G. Kienzle, "Multitasking in high-speed interconnection systems.", Computer Networks and ISDN Systems, Vol. 25 No. 6, Jan 1993, p 701-716.

- van Praag, A.; Anguelov, T.; Burckhart, D.; McLaren, R. A.; van der Bij, H. C.; Bovier, J.; Cristin, P.; Haben, M.; Jovanovic, P.; Kenyon, I.; Staley, R.; Cunningham, D.; Watson, G.; Green, B.; Strong, J., "HIPPI developments for CERN experiments.", IEEE Transactions on Nuclear Science, Vol. 39 No. 4, Aug 1992. p 880-885.

- K. Hung-Chang, A. Nilsson, D. Winkelstein, L. Bottomley, "Traffic Measurements on HIPPI Links in a Super-computing Environment", in "Asynchronous Transfer Mode Networks", edited by Y. Viniotis and R. O. Onvural, Plenum Press, New York, 1993.

FC References: Books

- *Fibre Channel: Connection to the future*, Fibre Channel Association, 800-272-4618, FCA-info@amcc.com, ISBN 1-878707-19-1, 1994, 56 pp.

- Alan F. Benner, *Fibre Channel*, McGraw Hill, ISBN 0-07-005669-2

- Jan Dedek, Ancot and Gary Stephens, *What Is Fibre Channel?*, FSI Consulting

- Jan Dedek, Ancot and Gary Stephens, *Fibre Channel, Volume 1, The Basics*, FSI Consulting

- *The Fibre Channel Bench Reference*, by Jeffrey D. Stai, ENDL Publications ISBN 1-879936-17-8, contact dal_allan@mcimail.com

FC Standards Organizations

❑ Fibre Channel Association, 12407 MoPac Expressway North 100-357, P.O. Box 9700, Austin, TX 78766-9700, Phone: 800-272-4618, 512-328-8422, FAX: 512-328-8423, Email: fca@amcc.com http://www.amdahl.com/ext/CARP/FCA/FCintro.html

❑ American National Standards Institute (ANSI) X3T11 committee

❑ Fibre Channel Systems Initiative (FCSI)

❑ Fibre Channel Consortium - University of New Hampshire Interoperability Lab

❑ Fibre Channel Loop Community (FCLC)

FC References: Papers

- ❑ X3T9.3 Task Group of ANSI: Fibre Channel Physical and Signaling Interface (FC-PH), Rev. 4.2 October 8, 1993

- ❑ Fibre Channel Overview-CERN High Speed Interconnect pages-15 August 1994-Erak van der Bij (http://www1.cern.ch/HSI/fcs/spec/overview.htm)

- ❑ Fibre Channel Association: Fibre Channel: Connection to the Future, 1994, ISBN 1-878707- 19-1

- ❑ Gary Kessler: Changing channels, LAN Magazine, December 1993, p69-78

- ❑ ANSI X3.230-1994, Fibre Channel Physical and Signaling Interface (FC-PH) Rev 4.3

Papers (Cont)

❑ Fibre Channel General Introduction,
   http://www.amdahl.com/ext/CARP/FCA/FCintro.html

❑ Welcome to the FCA server,
   http://www.amdahl.com/ext/CARP/FCA/FCA.html

❑ EGDE, on & about AT& T, March 20, 1995 v10 n347
   p25(1)

❑ Special Report: Fibre Channel Association(FCA), The
   LocalNetter, May 1994 v14 n5 p57(1)

FC References: Standards

❑ The following are available at
http://www.amdahl.com/ext/CARP/FCA/

❑ FC Physical (FC-PH), documents and reference card

❑ FC Reference Card

❑ FC-PH-2 Rev 7.3

❑ FC-PH-3 Rev 8.3

❑ FC Arbitrated Loop (FC-AL)

❑ FC Protocol for SCSI (FCP)

❑ FC Protocol for 802.2LE (FC-LE)

❑ FC Protocol for HIPPI (FC-FP)

❑ FC Protocol for SBCON (FC-SB)

- SBCON, home page
- FC-SB Rev 3.4
- FC Generic Services (FC-GS)
- FC-GS Rev 3.0

FC Profiles

- FCSI Profiles

- FCSI Profile Structure, FCSI-001 Rev 1.0

- FCSI Common FC-PH Feature Sets, FCSI-101 Rev 3.0

- FCSI SCSI Profile, FCSI-201 Rev 2.1

- FCSI IP Profile, FCSI-202 Rev 2.0

- Gigabit Link Module Specification, FCSI-301 Rev 1.0

- Direct Disk Attach Profiles + Direct Disk Attach Profile, prv_130.ps Rev 1.3.0

- FC-AL Direct Disk Attach Minutes

Related Specifications

❏ Private Loop Direct Attach document Rev 1.0

❏ N_Port-to-F_Port Interoperability, Version 1.0

❏ 10-Bit Interface Specification, documents

❏ Fabric Element MIB, draft-teow-fabric-mib-00.txt

❏ Node MIB, draft-chu-fibre-channel-mib-03.txt

ANSI Templates.

❏ FrameMaker 4.0 ANSI style Fibre Channel templates Rev 4.0

Recent Advances in Networking and Telecommunications Seminar Series 1996: Tentative Dates

Last Tuesday of the month (mostly), 3:45-5:15 PM

- January 30, 1996
- February 27, 1996
- March 21, 1996
- April 30, 1996
- May 28, 1996
- June 18, 1996
- August 27, 1996
- September 24, 1996
- October 15, 1996
- November 26, 1996

The Ohio State University

Raj Jain

Potential Topics for 1996

✓ Internet Protocol: Next Generation

✓ Gigabit Networking Standards: Fibre Channel and HIPPI

❑ Technologies for 6 Mb/s to Home: ADSL, HDSL

❑ GPS Applications to Networking

❑ Satellite Networking

❑ Latest developments in Multimedia over IP

❑ New Advances in Wireless Networking

❑ Cellular Digital Packet Data (CDPD)

❑ Routing on ATM Networks

❑ Multiprotocol over ATM

Suggestions for topics welcome

Thank You!

❑ The purpose of the seminar is technology transfer. We want to help Columbus/Ohio businesses be on the leading edge of the technology superhighway. Thank you for attending the seminar.

❑ If your company would like to sponsor partly, please contact Jain@cis.ohio-state.edu

❑ Slides of all past seminars and all our papers and reports can be obtained on-line:
http://www.cis.ohio-state.edu/~jain/

❑ To get on our list, (if not already on), Email requests to NetSem@CIS.Ohio-state.edu

Seminar Registration

If you have not registered before or if your information has changed, please fill this out, tear this part, and leave it with the speaker. We will inform you about our future seminars.

Name: _____

Position (Title): _____

Company:_____

Address:_____

_____

_____

Phone: _____ Fax: _____

Email: _____