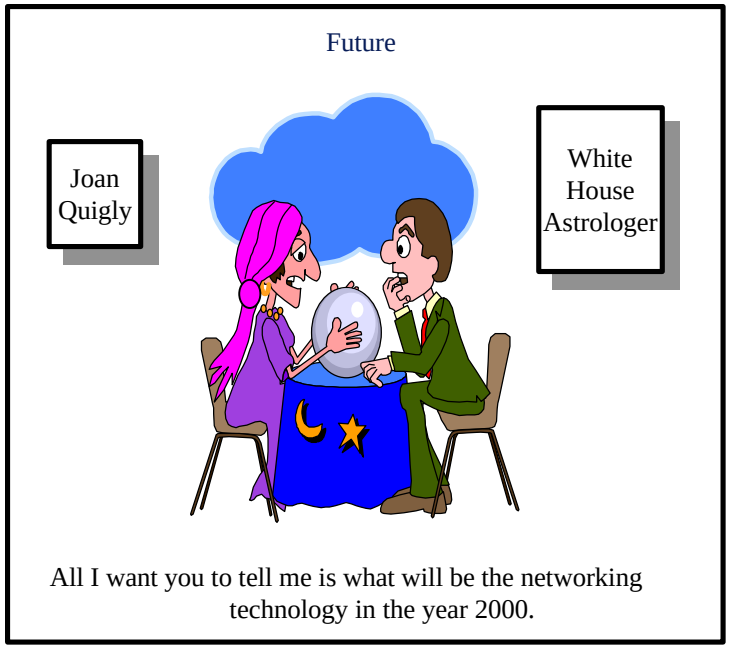
High-Speed Networking: Trends and Issues



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- Networking Trends
- Life Cycle of Technologies
- Trends in Applications
- Issues: Economy of scale, Performance Bottleneck

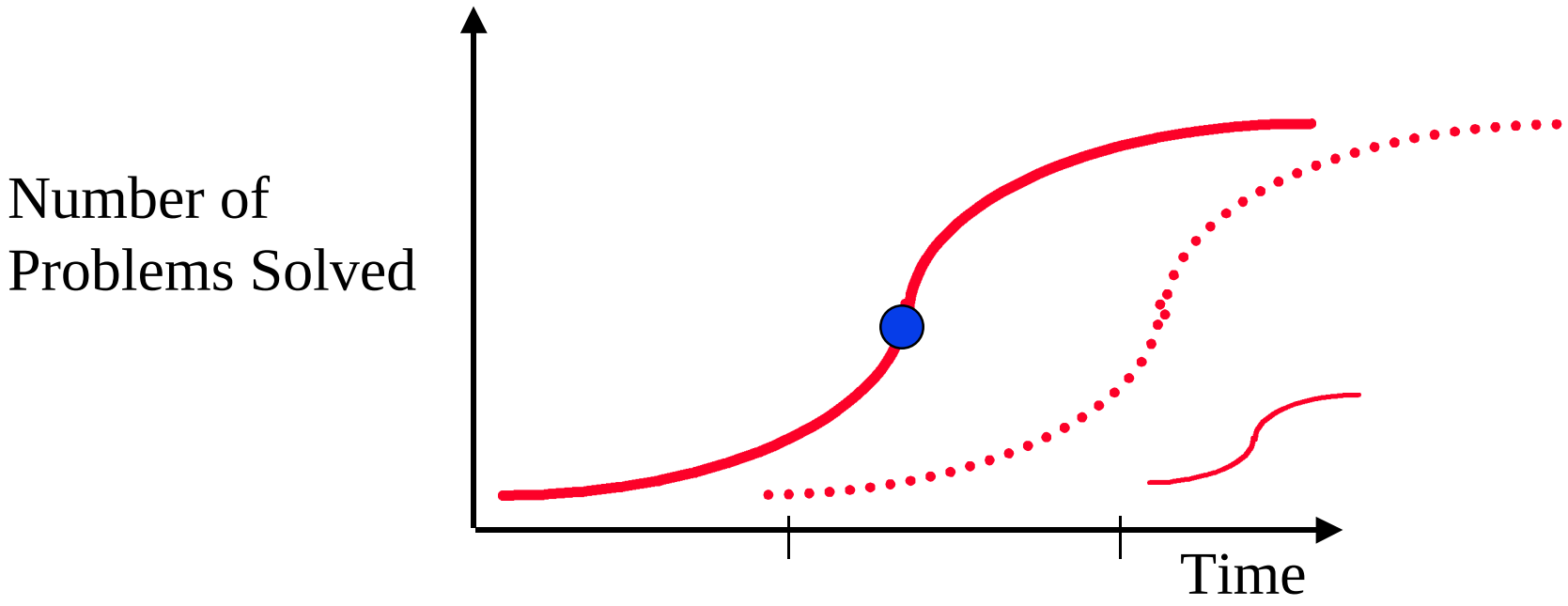
Ref: R. Jain, FDDI Handbook: High-Speed Networking using Fiber and Other Media," Addison-Wesley, Reading, MA 01867, Phone: (800)822-6339, (617)944-3700X2391, Fax: (800)333-3328, (617)944-7273, Email: MaureenC@AW.Com, ISBN: 0-201-56376-4, April 1994.

Trend: Telecommunication and Networking

- From computerization of telephone traffic switching to telephonization of computer traffic switching.
- Communication more critical than computing
  ⇒ Bus performance vs ALU speed
  ⇒ I/O performance vs SPECMarks
- User Location:
  - 1960: Computer room
  - 1970: Terminal room
  - 1980: Desktop
  - 1990: Mobile
- System Extent:
  - 1980: 1 Node within 10 m
  - 1990: 100 nodes within 10 km

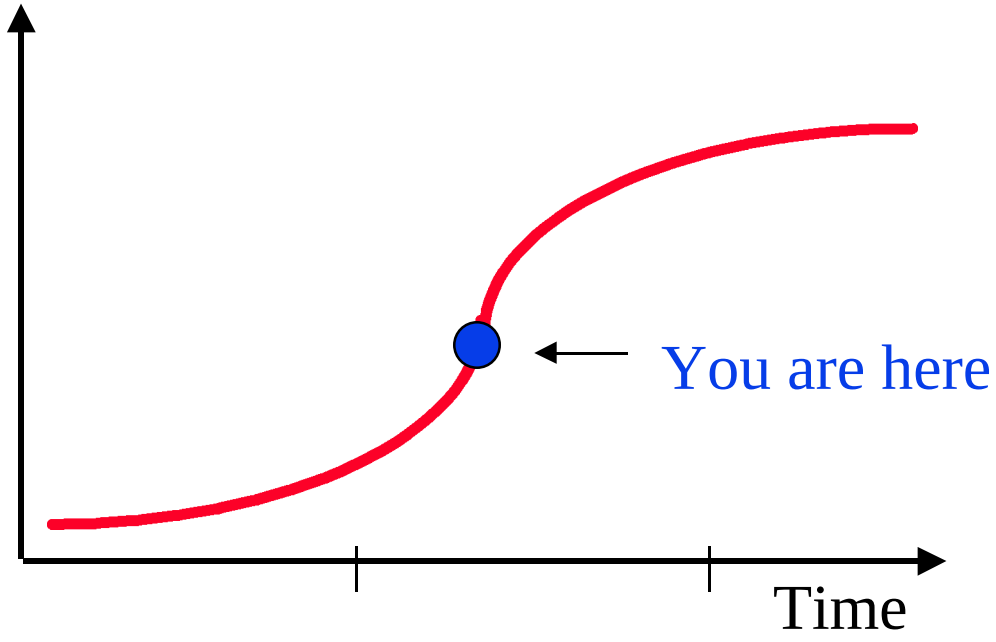
- Last 10 years: Individual computing
  Next 10 years: Cooperative computing
- Past: Corporate networks
  Future:
  - Intercorporate networks
  - National Info Infrastructures
  - International Info Infrastructures

Life Cycles of Technologies

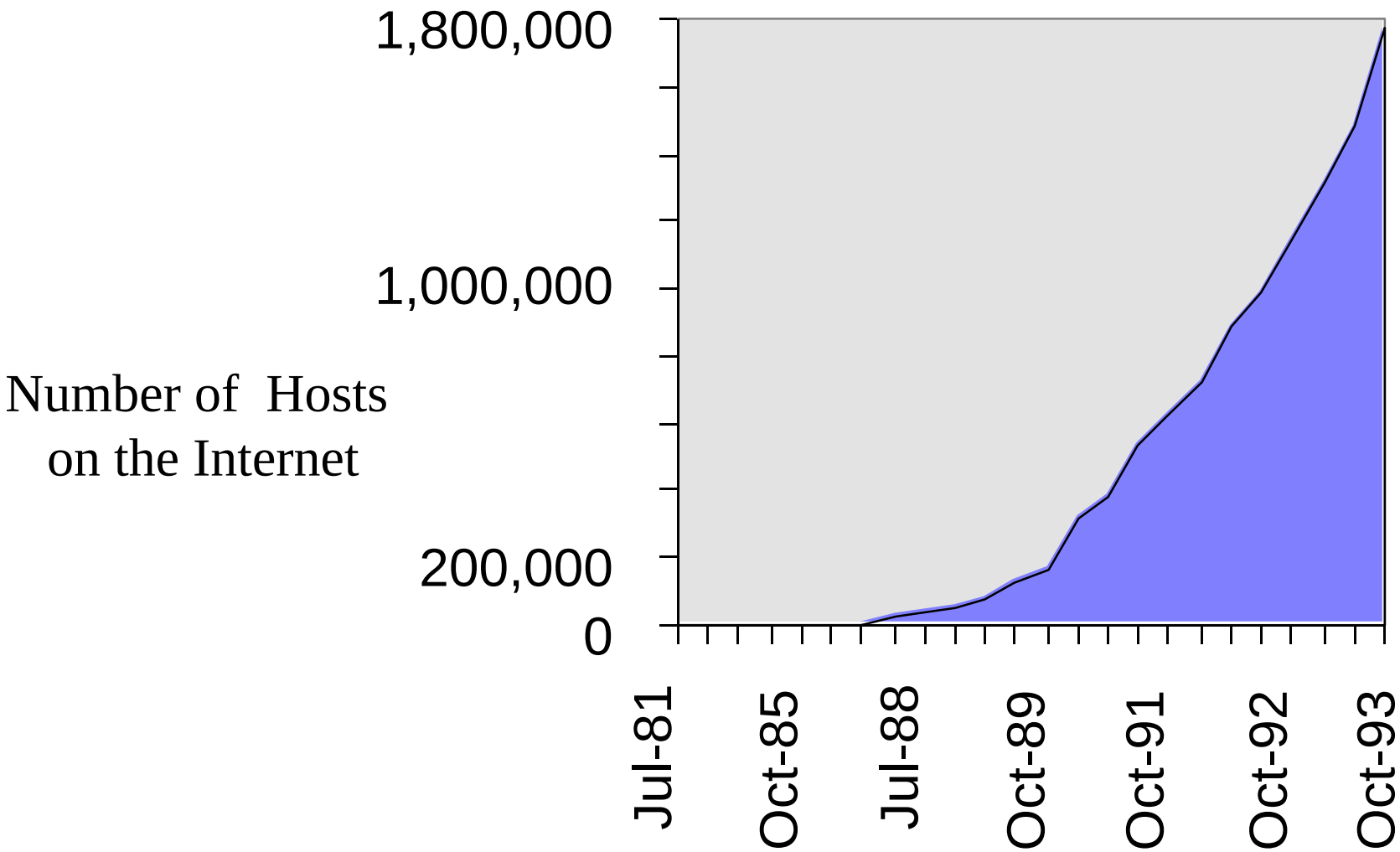


Life Cycles of Networking Technology

Number of Hosts
Bytes per Hosts
Number of Networks
MIPS
Memory Size
Storage



Trend: Exponential Growth

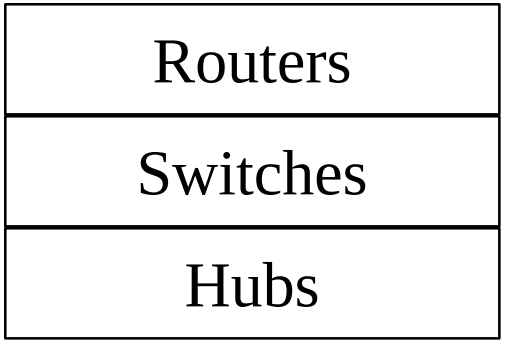


Networking in Social Fabric

- USENET: Ten million news articles/month
- 18 on-line coffee houses in San Francisco
- National Public Radio Program
- Supreme court decision within one day
- Real estate, on-line catalog
- 137 countries reachable via Email

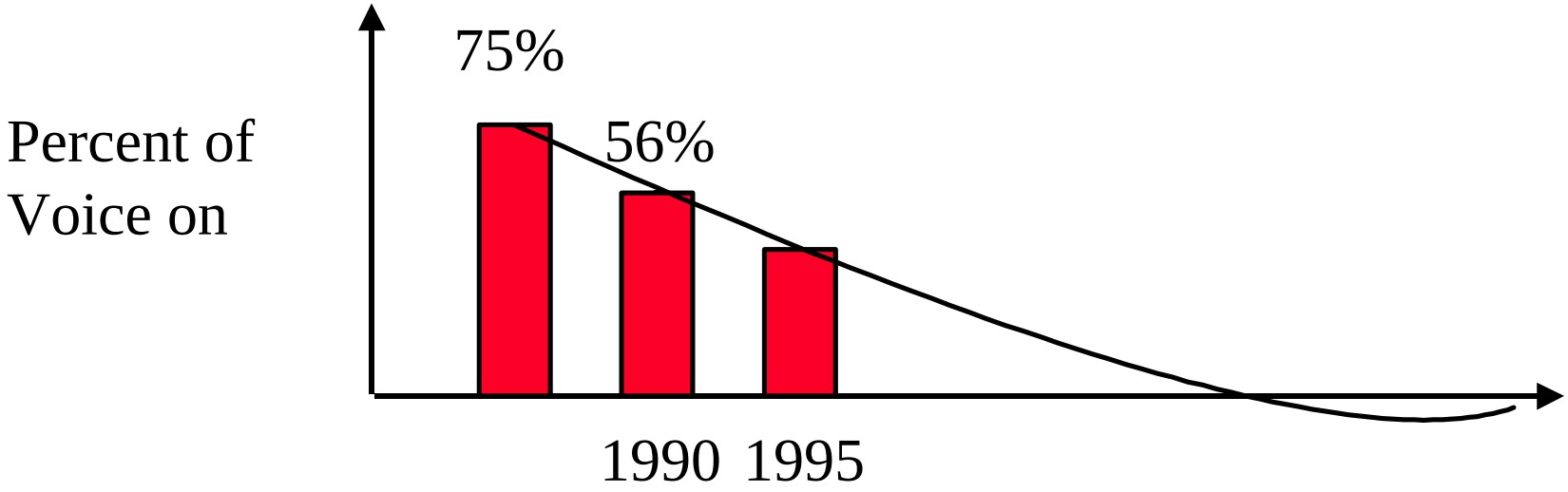
Trend: Standardization

- Religion must be forgotten
  ⇒ Improve on someone else's ideas as naturally as yours
- Can't succeed alone
  ⇒ Innovation + Technology partnerships
- To impact: Participate in standardization
  Publication is too late and insufficient
- Vertical vs horizontal specialization
  ⇒ Switch, router, host, applications



Trends in Applications

- Little Voice
- AT&T: 125 to 130 M calls/day @ 5 min/call 64 kbps = 28.8 Gbps = 1/1000 of one fiber
- 200 Million X 24 hr/day X 64 kbps = 12.8 Tbps
- Survey of 1750 businesses:



- Ref: IEEE Spectrum, August 1992, p 19.

Networking Failures vs Successes

- 1980: Broadband (vs baseband)
- 1981: PBX (vs Ethernet)
- 1984: ISDN (vs Modems)
- 1986: MAP/TOP (vs Ethernet)
- 1988: OSI (vs TCP/IP)
- 1991: DQDB
- 1992: XTP (vs TCP)

Requirements for Success

- Low Cost
- High Performance
- Killer Applications
- Timely completion
- Manageability
- Interoperability
- Coexistence with legacy LANs
  Existing infrastructure is more important than new technology

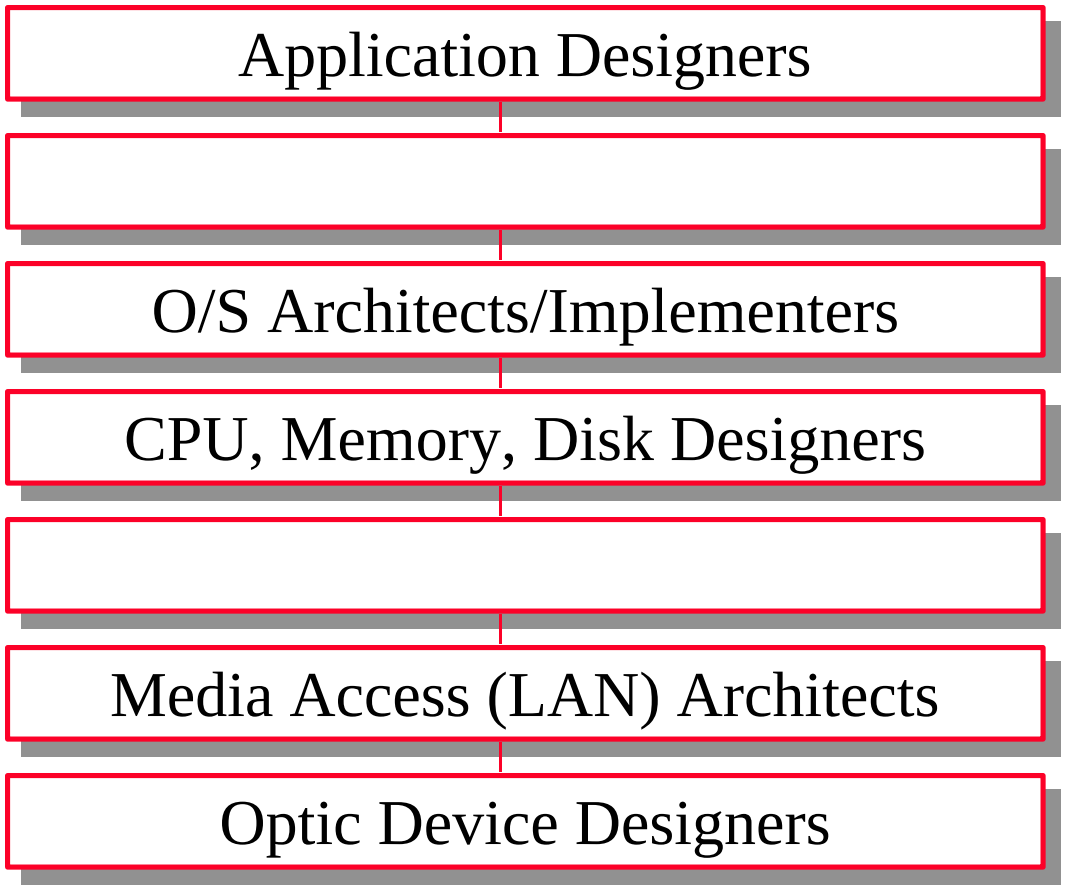
Challenge: Economy of Scale

- Technology is far ahead of the applications.
  Invention is becoming the mother of necessity.
  We have high speed fibers, but not enough video traffic.
- Low-cost is the primary motivator. Not necessity.
  $\Rightarrow$ Buyer's market (Like $99 airline tickets to Bahamas.)
  Why? vs Why not?
- Ten 100-MIPS computer are cheaper than one 1000-MIPS computer $\Rightarrow$ Parallel computing, not supercomputing
- Ethernet was and still is cheaper than 10 one-Mbps links.
- No FDDI if it is 10 times as expensive as Ethernet.
  10/100 Ethernet adapters = $50 over 10 Mbps
- Q: Given ATM or 100 Mbps Ethernet at the same cost, which network will you buy?
  A: Ethernet. Proven Technology.

Challenge: Tariff

- High-speed is important for LANs
  Low-cost is critical for WANs.
- Phone company's goal: How to keep the voice business and get into data too?
- Customer's goal: How to transmit the data cheaper?
- Tariff Today:
  - 64 kbps voice line = $300/year
  - 45 Mbps line (coast to coast) = $180 k-240 k/year
    $\Rightarrow$ 155 Mbps line = $540 k - $720 k/year
- Tomorrow: 155 Mbps = $1k/month+ $28/G cells
  $\Rightarrow$ $13k - $45k/year

Challenge: Performance



Video Coding, FTP

UNIX, DOS

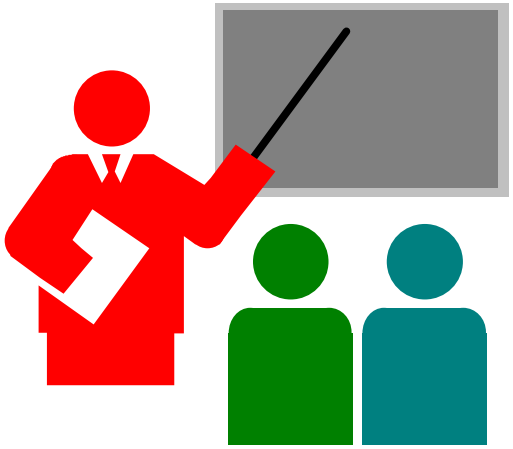
Pentium, Alpha

FDDI, ATM

Fibers, Lasers

- Faster link ≠ Faster applications
- Need to consider trends of all layers

Summary



- Networking is critical and growing exponentially.
- Computer and Telecommunications industry merging
- High-speed links iff economy of scale.
- If users can't see it, they will not pay for it.
- Shared switching rather than shared media

References

All our papers are available on-line at:
http://www.cis.ohio-state.edu/~jain/papers/

- Raj Jain, “ATM Networking: Issues and Challanges,” NetWorld+InterOp Engineering Conference, Las Vegas, April 1995.
- K. Siu and R. Jain, "A Brief Overview of ATM: Protocol Layers, LAN Emulation, and Traffic Management," Computer Communications Review (ACM SIGCOMM), April 1995.
- R.Jain, "Congestion Control and Traffic Management in ATM Networks: Recent Advances and A Survey", Invited submission to Computer Networks and ISDN Systems, February 1995.

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- D. Clark and D. Tennenhouse, "Architectural Considerations for a New Generation of Protocols," Proc. SIGCOMM-90, pp. 200-208, August 1990..
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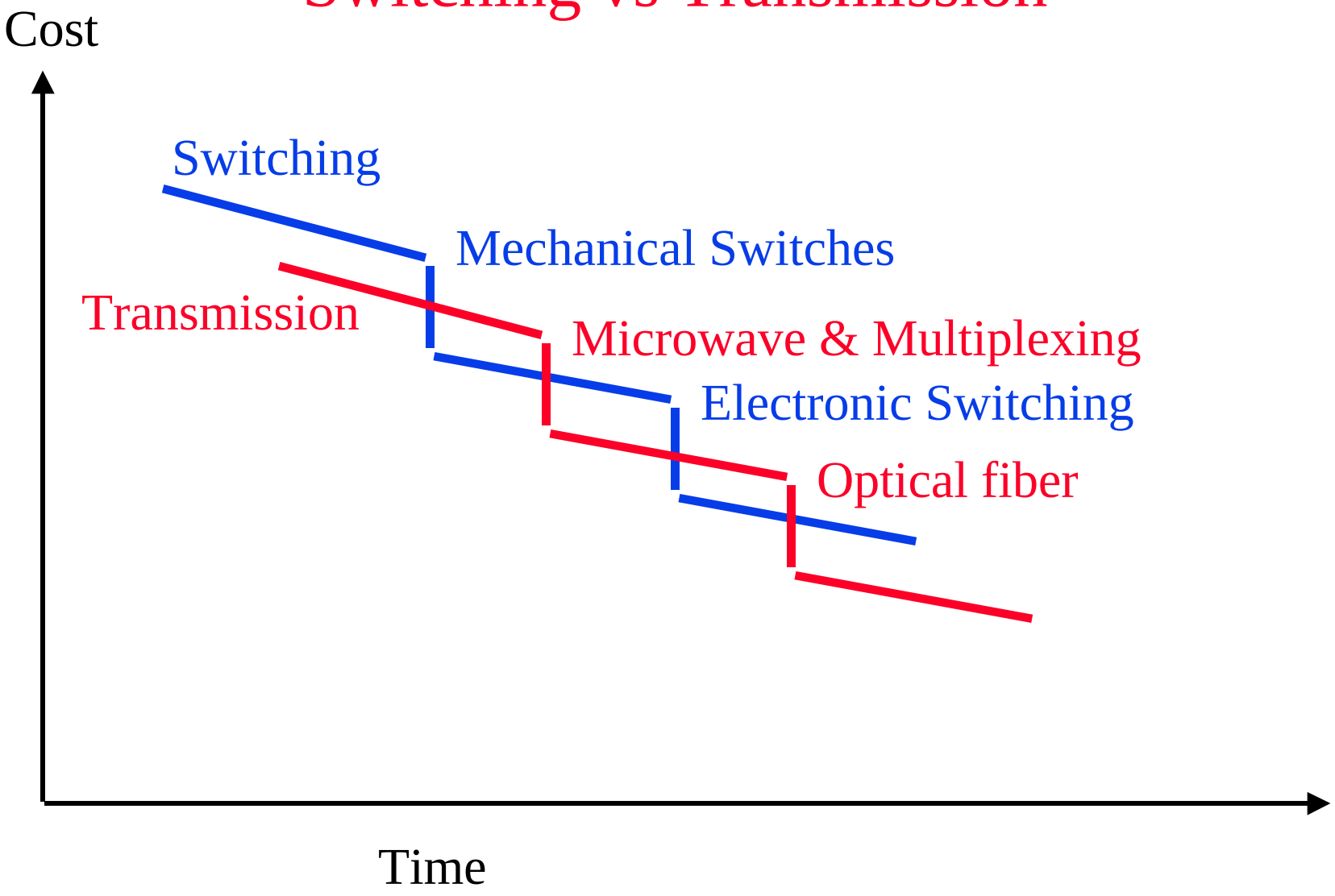
- Craig Partridge, "Building Gigabit Network Interfaces," ConneXions, 1993.
- J. Smith and C. Traw, "Giving Applications Access to Gb/s Network," IEEE Network, July 1993.

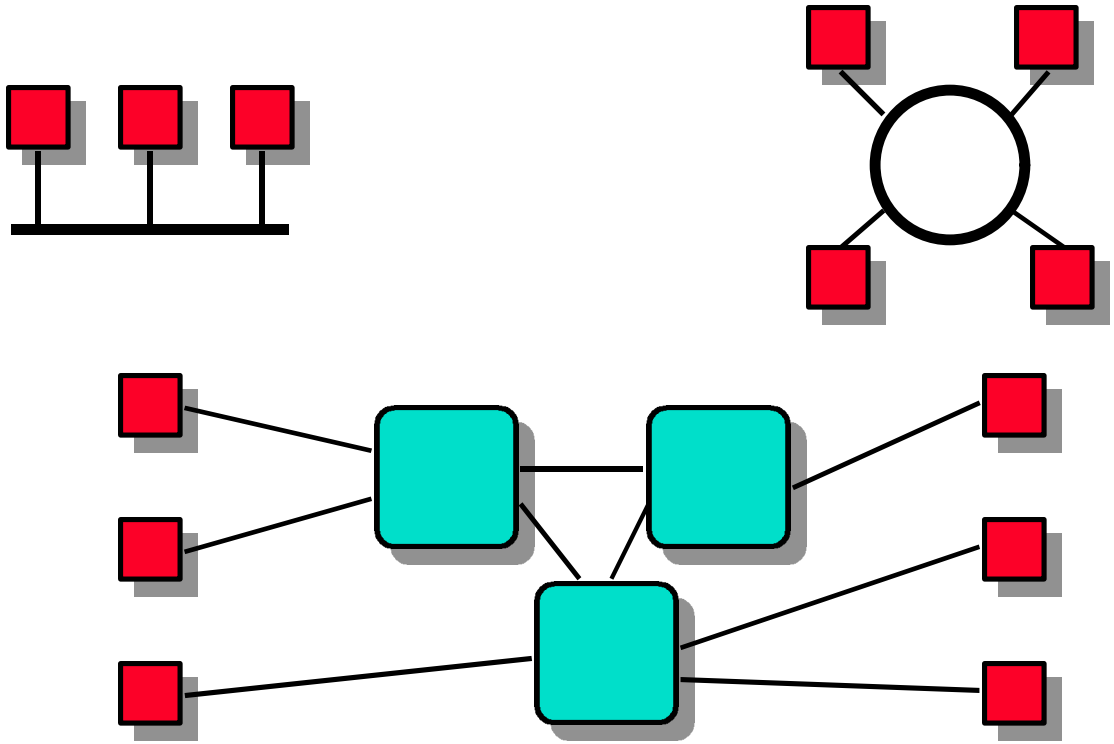
Electro-optic Bottleneck

- Bandwidth of fiber = 25 THz/window
- Bandwidth of electronics = 1-10 Gbps
- Switching bottleneck
  $\Rightarrow$ Optical switching $\Rightarrow$ All-optical networks
- Switching bottleneck
  $\Rightarrow$ Switches more expensive than media
  $\Rightarrow$ Less switches and more links
- Higher connectivity, less hops
- Distributed media shared switching (like WANs) and not distributed switching shared media (like LANs)

Switching vs Transmission



Shared Media vs Shared Switches



- Variable bandwidth/station
- Cost ∝ bandwidth
- Incremental upgradability
- Natural spatial reuse

Thank You!