
Networking Trends and Their Impact



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<http://www.cis.ohio-state.edu/~jain/cis788-99/>



Technology Trends

Networking Trends

Technology Trends

Networking Bottleneck

Fast Immediacy

Impact on R&D

Impact on Education

Convergence

Information Glut

Trends: Networking Bottleneck

Communication is more critical than computing

- Greeting cards contain more computing power than all computers before 1950.
- Genesis's game has more processing than 1976 Cray supercomputer.

Networking speed is the key to productivity

E-Commerce \Rightarrow 20-30% of revenue spent on networking

High bandwidth \Rightarrow More bits per second

Hundreds of telegrams per day \Rightarrow Fast pace of life

Impact on R&D

Too much growth in one year

⇒ Can't plan too much into long term

Long term = 1₂ year or 10₂ years at most

Products have life span of 1 year, 1 month, ...

Short product development cycles.

Chrysler reduced new car design time

from 6 years to 2.

Distance between research and products has narrowed

⇒ Collaboration between researchers and developers

⇒ Academics need to participate in industry consortia

Impact on Education

Technology is changing faster than our ability to learn

⇒ Your value (salary) decreases with experience (years out of college)

Recent graduates know C++, HTML, Java, TCP/IP,

Need personal career management strategies

New Opportunities/Challenges for educators

New challenges for learners

Trend: Convergence

entertainment
video Games
publishing
news

advertising

Cable TV

Telephone

Computer

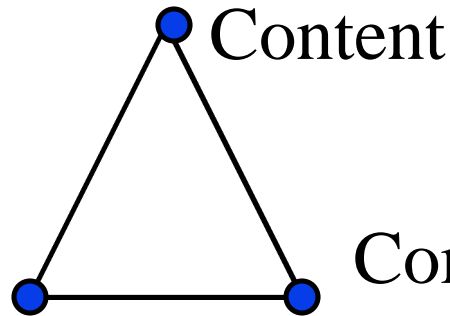
Digital
Media
Production

Video
Transport

Voice
Transport

Digital Media
Storage/
Handling

Convergence (Cont)



Computing

Communications

Merging of Content Providers and Content transporters

Phone companies, cable companies, entertainment industry, and computer companies

Single department for telephone and computer networking

LAN/WAN convergence

Trend: Information Glut

Web \Rightarrow Information production and dissemination costs are almost zero

\Rightarrow Too much information
= Needles in the haystack

Thousands of hits on each search

Need tools for summarizing the information

Opportunities for artificial intelligence

Need to express information so that both human and computers can understand

Networking Trends

Faster Media

More Traffic

Traffic > Capacity

ATM in Backbone

Everything over IP

Traffic Engineering

All-layer Routing

Trend: Faster Media

One Gbps over 4-pair UTP-5 up to 100 m
10G being discussed.

Was 1 Mbps (1Base-5) in 1984.

Dense Wavelength Division Multiplexing (DWDM)

54×OC-192 = 0.6 Tbps

OC-768 = 40 Gbps over a 1λ to 65 km [Alcatel98]

100 Gbps using 80λ products.

Was 100 Mbps (FDDI) in 1993.

11 Mbps in-building wireless networks

Was 1 Mbps (IEEE 802.11) in 1998.

2.5 Gbps to 5km using light in open air

Trend: Faster Media

One Gbps over 4-pair UTP-5 up to 100 m
Was 1 Mbps (1Base-5) in 1984.

Dense Wavelength Division Multiplexing (DWDM)
allows 64 wavelengths in a single fiber

$54 \times \text{OC-192} = 0.6 \text{ Tbps}$

$\text{OC-768} = 40 \text{ Gbps}$ demonstrated in 1998.

Was 100 Mbps (FDDI) in 1993.

11 Mbps in-building wireless networks

Was 1 Mbps (IEEE 802.11) in 1998.

Trend: More Traffic

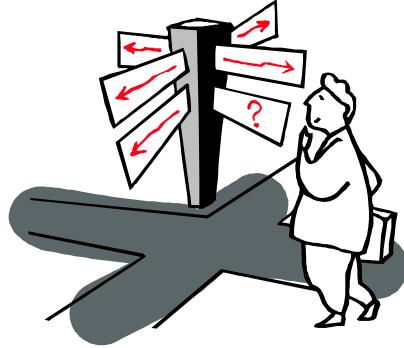


Number of Internet hosts is growing super-exponentially.

Traffic per host is increasing:

- Cable modems allow 1 to 10 Mbps access from home
 - 6-27 Mbps over phone lines using ADSL/VDSL
- Bandwidth requirements are doubling every 4 months

Trend: Traffic > Capacity



Expensive Bandwidth

Sharing

Multicast

Virtual Private Networks

Need QoS

Likely in WANs

Cheap Bandwidth

No sharing

Unicast

Private Networks

QoS less of an issue

Possible in LANs

Trend: ATM in Backbone

Most carriers including AT&T, MCI, Sprint, UUNET have ATM backbone

Over 80% of the internet traffic goes over ATM

ATM provides:

- Traffic management
- Voice + Data Integration: CBR, VBR, ABR, UBR
- Signaling
- Quality of service routing: PNNI

ATM can't reach desktop: Designed by carriers.

Complexity in the end systems. Design favors voice

Trend: Everything over IP

Data over IP \Rightarrow IP needs Traffic engineering

Voice over IP \Rightarrow Quality of Service and Signaling

Internet Engineering Task Force (IETF) is the center of action.

Attendance at ATM Forum and ITU is down.

Trend: Traffic Engineering

User's Performance Optimization

⇒ Maximum throughput, Min delay, min loss, min delay variation

Efficient resource allocation for the provider

⇒ Efficient Utilization of all links

⇒ Load Balancing on parallel paths

⇒ Minimize buffer utilization

○ Current routing protocols (e.g., RIP and OSPF) find the shortest path (may be over-utilized).

QoS Guarantee: Selecting paths that can meet QoS

Enforce Service Level agreements

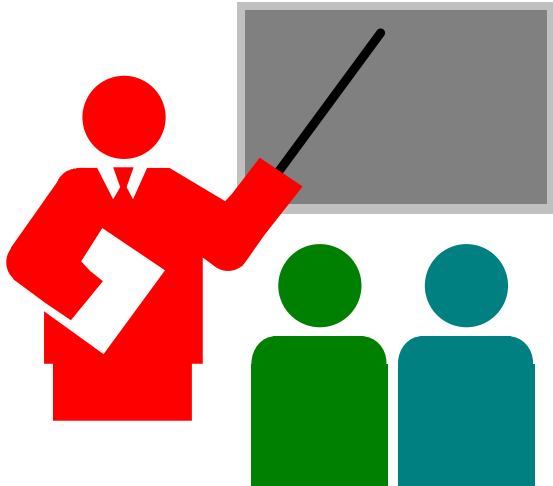
Enforce policies: Constraint based routing \supseteq QoSR

Trend: All-Layer Routing

Old: All packets followed the same path, stood in the same FIFO queue. Path based on Destination IP Address.

New: Buffering, Queueing, Scheduling, and path based on Destination IP address, Source IP address, TCP Ports, Type of Service, ...

Summary



Networking is growing exponentially

it is impacting all aspects of life \Rightarrow Networking Age

Profusion of Information

Virtualization, Globalization, Immediacy

References

See Reference on Networking history and trends,
http://www.cis.ohio-state.edu/~jain/refs/ref_trnd.htm

Books on Networking history and trends,
http://www.cis.ohio-state.edu/~jain/refs/trn_book.htm