Networking Trends and Their Impact

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These Slides are available on-line at

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

Overview

❑ Technology Trends

❑ Networking Trends

Technology Trends

1. Networking Bottleneck
2. Fast Immediacy
    Impact on R&D
    Impact on Education
3. Convergence
4. Information Glut

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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

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Impact on R&D

❏ Too much growth in one year
   $\Rightarrow$ Can't plan too much into long term

❏ Long term = 1_2 year or 10_2 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
   $\Rightarrow$ Collaboration between researchers and developers
   $\Rightarrow$ Academics need to participate in industry consortia

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Impact on Education

❏ Technology is changing faster than our
   ability to learn
   $\Rightarrow$ 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

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Trend: Convergence

Entertainment
Video Games
Publishing
News
Advertising   Cable TV   Telephone   Computer

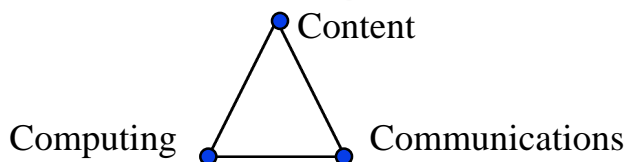| Digital Media Production	Video Transport	Voice Transport	Digital Media Storage/ Handling

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Convergence (Cont)

Content

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)
$64\times$OC-192 = 0.6 Tbps
OC-768 = 40 Gbps over a 1λ to 65 km [Alcatel98]
400 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
$64\times$OC-192 = 0.6 Tbps
OC-768 = 40 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

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Trend: Traffic > Capacity

Expensive Bandwidth	Cheap Bandwidth
❑ Sharing	No sharing
❑ Multicast	Unicast
❑ Virtual Private Networks	Private Networks
❑ Need QoS	QoS less of an issue
❑ Likely in WANs	Possible in LANs

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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
$\Rightarrow$ Maximum throughput, Min delay, min loss, min delay variation
❑ Efficient resource allocation for the provider
  $\Rightarrow$ Efficient Utilization of all links
  $\Rightarrow$ Load Balancing on parallel paths
  $\Rightarrow$ 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
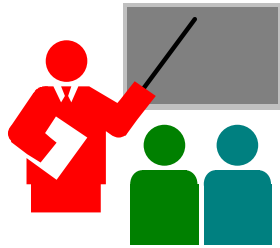❑ Enforce policies: Constraint based routing $\supseteq$ QoSR

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