Computer Networking: Recent Developments, Trends, and Issues

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These Slides are available at

http://www.cse.wustl.edu/~jain/talks/icpads05.htm

Overview

1. **Industry Trends**

   1. Top 10 Networking Developments of 2004

   2. Networking Technologies: Failures vs Successes

2. **Research Trends**

   1. Top 5 Networking Research Topics

   2. Recent DARPA/NSF Funding Opportunities

Top 10 Networking Developments of 2004

1. Large investments in Security: Message Aware Networking
   $\Rightarrow$ All messages scanned by security gateways

2. Wireless (WiFi) is spreading (Intel Centrino)

3. More Cell phones than POTS.
   Smart Cell phones w PDA, email, video, images $\Rightarrow$ Mobility

4. Broadband Access is growing faster than cell phones
   Fiber is creeping towards home

5. Ethernet extending from Enterprise to Access to Metro …

6. Wiring more expensive than equipment $\Rightarrow$ Wireless Access

7. Multi-Protocol Label Switching for traffic engineering

8. Voice over Internet Protocol (VOIP) is in the Mainstream

9. Multi-service IP: Voice, Video, and Data

10. Terabyte/Petabyte storage (Not VoD) $\Rightarrow$ High-Speed Networking
    Grid Storage. Desktop search.

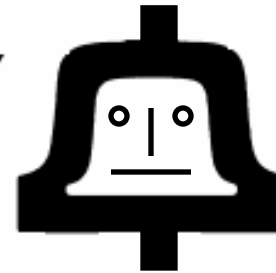# Convergence

Protocols
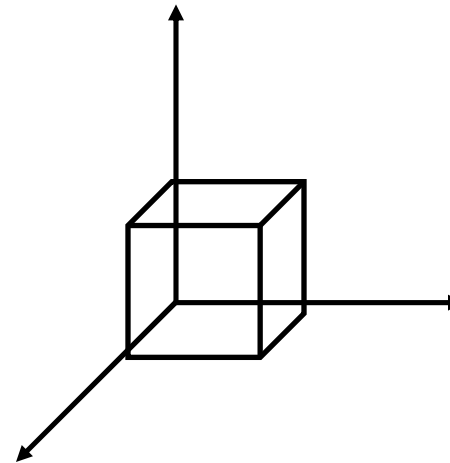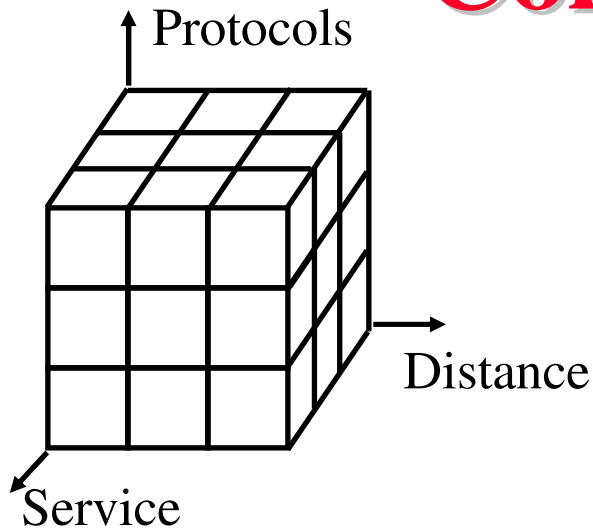
Distance

Service

- ❏ Distance: LAN vs MAN
- ❏ Services: Data, Voice, Video
- ❏ Phy: Circuit switched vs Packet switched
- ❏ L2 Protocols: Ethernet and SONET
- ❏ L3 Protocols: IP
- ❏ HTTP: Hyper-Application Access protocol

Ethernet: 1G vs 10G Designs
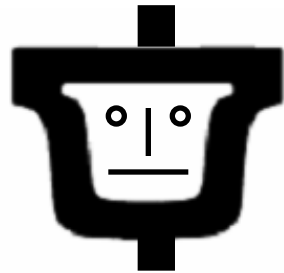
1G Ethernet

- 1000 / ~~800~~ / ~~622~~ Mbps
  Single data rate
- **LAN** distances only
- No Full-duplex only
  ⇒ **Shared** Mode
- Changes to **CSMA/CD**

10G Ethernet

- 10.0/9.5 Gbps
  Both rates.
- LAN and **MAN** distances
- Full-duplex only
  ⇒ **No Shared** Mode
- **No CSMA/CD** protocol
  ⇒ No distance limit due to MAC
  ⇒ *Ethernet* End-to-End

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Networking: Failures vs Successes

❏ 1980: Broadband (vs baseband) Ethernet
❏ 1984: ISDN (vs Modems)
❏ 1986: MAP/TOP (vs Ethernet)
❏ 1988: Open System Interconnection (OSI) vs TCP/IP
❏ 1991: Distributed Queue Dual Bus (DQDB)
❏ 1994: CMIP (vs SNMP)
❏ 1995: FDDI (vs Ethernet)
❏ 1996: 100BASE-VG or AnyLan (vs Ethernet)
❏ 1997: ATM to Desktop (vs Ethernet)
❏ 1998: Integrated Services (vs MPLS)
❏ 1999: Token Rings (vs Ethernet)

Requirements for Success

❏ Low Cost: Low startup cost $\Rightarrow$ Evolution

❏ High Performance

❏ Killer Applications

❏ Timely completion

❏ Manageability

❏ Interoperability

❏ Coexistence with legacy networks
  Existing infrastructure is more important than new
 technology (IPv4 vs IPv6, Overcast vs IP multicast)

Access Networks

❑ 63.84 M DSL subscribers worldwide. 2003 growth rate of 77.8% is more than the peak growth rate of cellular phones.

❑ By Q3'04, 19M Cable Modems, 12M DSL in USA [Leichtman Research]

❑ All countries are racing to a leadership position in broadband

❑ Digital-Divide $\Rightarrow$ 30M subs@10Mbps, 10M@100Mbps in Japan by 2005

❑ Telecom epicenter has moved from NA+Europe to Asia Pacific

Rank	Country	DSL per 100 Phones	Rank	Country	DSL per 100 Phones
1	South Korea	28.3	6	Israel	14.5
2	Taiwan	19.8	7	Denmark	14.2
3	Belgium	16.7	8	Finland	13.6
4	Hong Kong	16.1	9	Singapore	13.4
5	Japan	15.7	10	France	12.1
			32	USA	5.6

Ethernet to the First Mile (EFM)

CATV

Electrical &
SONET/SDH

T1/E1

Internet

VoIP

Video

Data

Voice
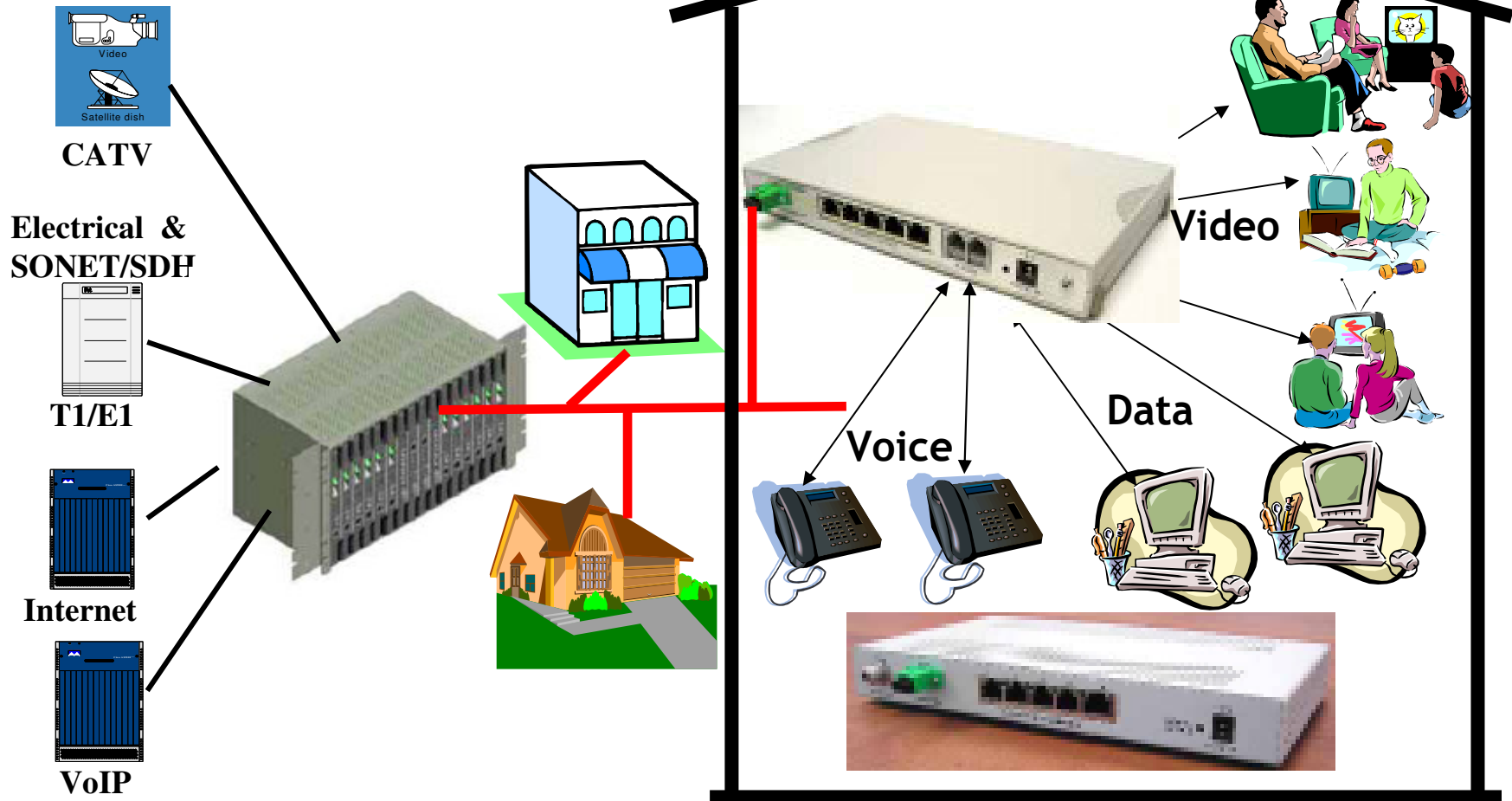
Telecom Revenue

	Revenue in Billions						
	2003	2004	2005	2006	2007	2008	Annual Growth
Video	0.2	0.3	.05	1.0	1.6	2.5	65.7%
Consumer Broadband	2.8	3.5	4.0	4.2	4.6	4.8	11.4%
Consumer long distance	20.7	18.2	16.0	13.6	11.3	9.2	-15.0%
Business local	26.3	26.7	26.4	26.1	25.8	25.5	-0.6%
Business long distance	26.1	24.5	23.0	21.3	19.7	18.2	-7.0%
Business data	44.8	45.6	46.6	47.1	46.8	45.4	0.3%
Consumer local	46.9	42.2	39.0	36.2	34.0	32.3	-7.25%
Wireless	91.5	108.7	119.2	132.8	144.5	153.6	10.9%
Total	260.7	271.5	277.0	285.0	291.3	294.9	2.5%

❏ Long distance is disappearing.

❏ Most of the revenues are going to be from wireless.

❏ Source: Instat/MDR (Business Week, Feb 28, 2005)

Wireless Industry Trends

- ❑ Wireless industry is stronger than wireline. Particularly strong growth in developing countries.

- ❑ 48% of global telco revenues coming from wireless

- ❑ 26% of wireless revenues coming from data (vs voice)

- ❑ Past: Voice, email, SMS, Ring tones

- ❑ Present: Push, Gaming, Pictures, Instant Messaging

- ❑ Future: Music, Video, Location, Remote monitoring, m-commerce

- ❑ Long Term: Video telephony, remote enterprise applications, remote management, Multiparty collaboration,

10 Challenges of Networking

1. **Size**: 4 nodes $\Rightarrow$ 100 M nodes $\Rightarrow$ 4B people $\Rightarrow$ 4T appliances
2. **Distance**: USA $\Rightarrow$ Worldwide $\Rightarrow$ Interplanetary $\Rightarrow$ WAN $\Rightarrow$ LAN $\Rightarrow$ PAN
3. **Speed**: 128 kbps $\Rightarrow$ 10Mbps $\Rightarrow$ 10Gbps $\Rightarrow$ 1.6 Tbps
4. **Criteria**: Least cost $\Rightarrow$ Policy based (Traffic Mgmt), Power
5. **Traffic**: Delay-tolerant Data, real-time voice and video, storage and computing
6. **Trust**ed nodes $\Rightarrow$ Secure, virus proof, spam proof, …
7. Stationary Nodes $\Rightarrow$ **Mobile** Nodes $\Rightarrow$ Mobile Networks
8. Stable Links $\Rightarrow$ Continuous **disruption**, long outages, Varying quality
9. Single ownership $\Rightarrow$ Multiple Domains $\Rightarrow$ **Hierarchies** of ownership
10. **Heterogeneity**: Single technology $\Rightarrow$ Multiple L1/L2/L3

Research Areas

1. **Disruption Tolerant Networking**: Frequent Disconnection due to mobility, power outage, DTN nodes have limited storage

2. **Overlay Networking**: Virtual Networks, P2P, Application level optimization

3. **Sensor Networks**: Large scale, Energy efficient

4. **Distributed Computing Networks** (Grids): Grid Storage

5. **Security**

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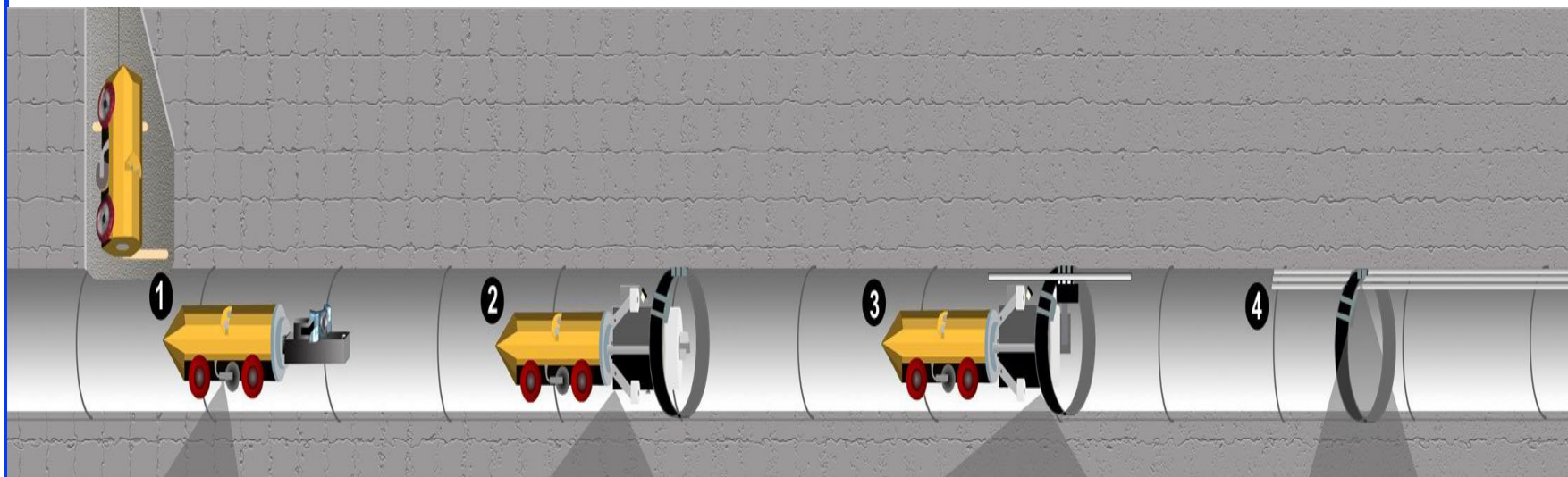Networks

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2004-05 DARPA BAAs

- **QoS**:
    - Switch architectures capable of end-to-end streams with **QoS** guarantees
    - Network **storage and caching** protocols for reducing long-haul communications loads
    - Cross-disciplinary approach to **modeling, analysis, and simulation** of wireless networks
    - Connectionless **wireless** networks.
    - **Situation-Aware Protocols** In Edge Network Technologies (SAPIENT): Auto-adapt protocols for application and network conditions.
- **Distributed Computing Networks**
    - Interconnecting heterogeneous systems through high speed network technology
    - Intelligent Metacomputing Center (computing via high performance networks)
    - Global Information **Grid** (Optical, satellite, wireless networks)
    - Gigabit stream access to remote assets over commercial networks
- **Security:**
    - Network Attack Traceback
    - Cyber Security Research and Development
    - Trustworthy computing in **mobile** environments
    - Host based security manager support
    - WAN firewalls and proxies for asymmetric data flows and speeds in excess of 5Gbps
    - Microprocessor/computing architectures to support secure computing
- **Optical:**
    - Fiber optics **sensor** technology
    - Wavelength division networking and soliton technology

Fiber Access Thru Sewer Tubes (FAST)

❏ Right of ways is difficult in dense urban areas

❏ Sewer Network: Completely connected system of pipes connecting every home and office

❏ Municipal Governments find it easier and more profitable to let you use sewer than dig street

❏ Installed in Zurich, Omaha, Albuquerque, Indianapolis, Vienna, Ft Worth, Scottsdale, ...

❏ Corrosion resistant inner ducts containing up to 216 fibers are mounted within sewer pipe using a robot called Sewer Access Module (SAM)

❏ Ref: http://www.citynettelecom.com, NFOEC 2001, pp. 331

FAST Installation

1. Robots map the pipe
2. Install rings
3. Install ducts
4. Thread fibers

Fast Restoration: Broken sewer pipes replaced with
   minimal disruption
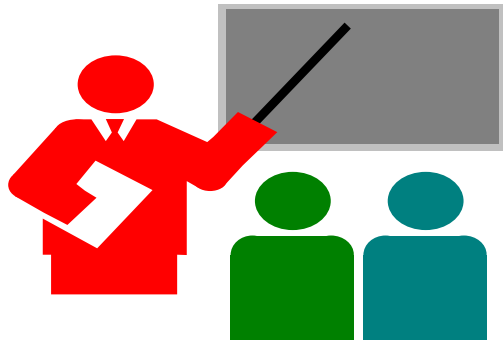
Summary

1. Networking is infrastructure and is now widely deployed. Evolution is more like to succeed than revolution.

2. Growing research opportunities in networking. Research areas and types of solutions required are different. All basic assumptions are being changed.

3. Wireless is where the action is. MIMO is in. CSMA/CD is out. L1:Wireless, L5-L7:Applications, L2-L4: Large scale

4. Key issues in Wireless are: Security, Mobility, and high-speed

Networking Trends: References

❏ References on Networking Trends,
  http://www.cse.ohio-state.edu/~jain/refs/ref_trnd.htm

❏ References on Optical Networking,
  http://www.cse.ohio-state.edu/~jain/refs/opt_refs.htm

❏ References on Residential Broadband,
  http://www.cse.ohio-state.edu/~jain/refs/rbb_refs.htm

❏ References on Wireless Networking,
  http://www.cse.ohio-state.edu/~jain/refs/wir_refs.htm