Computer Networking: Recent Developments, Trends, and Issues

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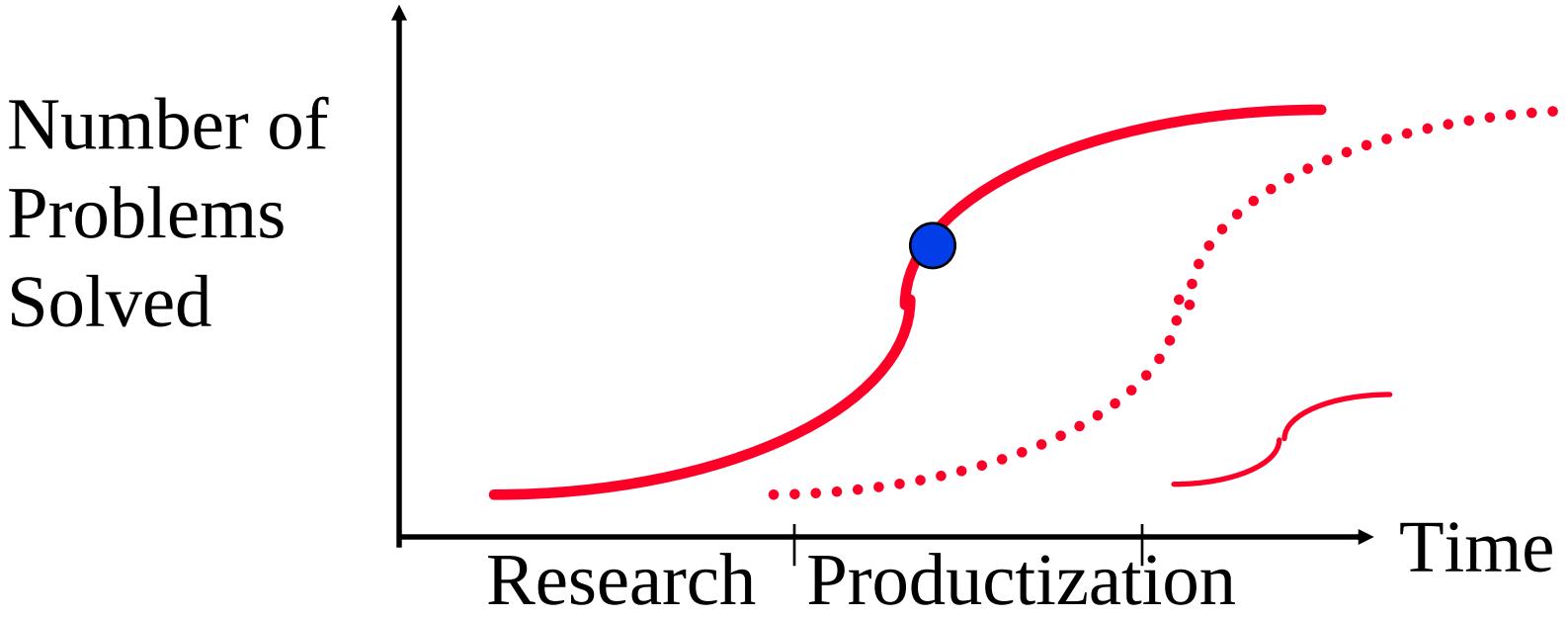
http:/www.cse.ohio-state.edu/~jain/talks/trends04.htm

- Impact of Networking
- Life Cycle of Networking Technologies
- Top 10 Developments of 2004
- Optical Networking Developments: Core, Metro, Access
- Networking Technologies: Failures vs Successes
- Wireless Networking: Issues

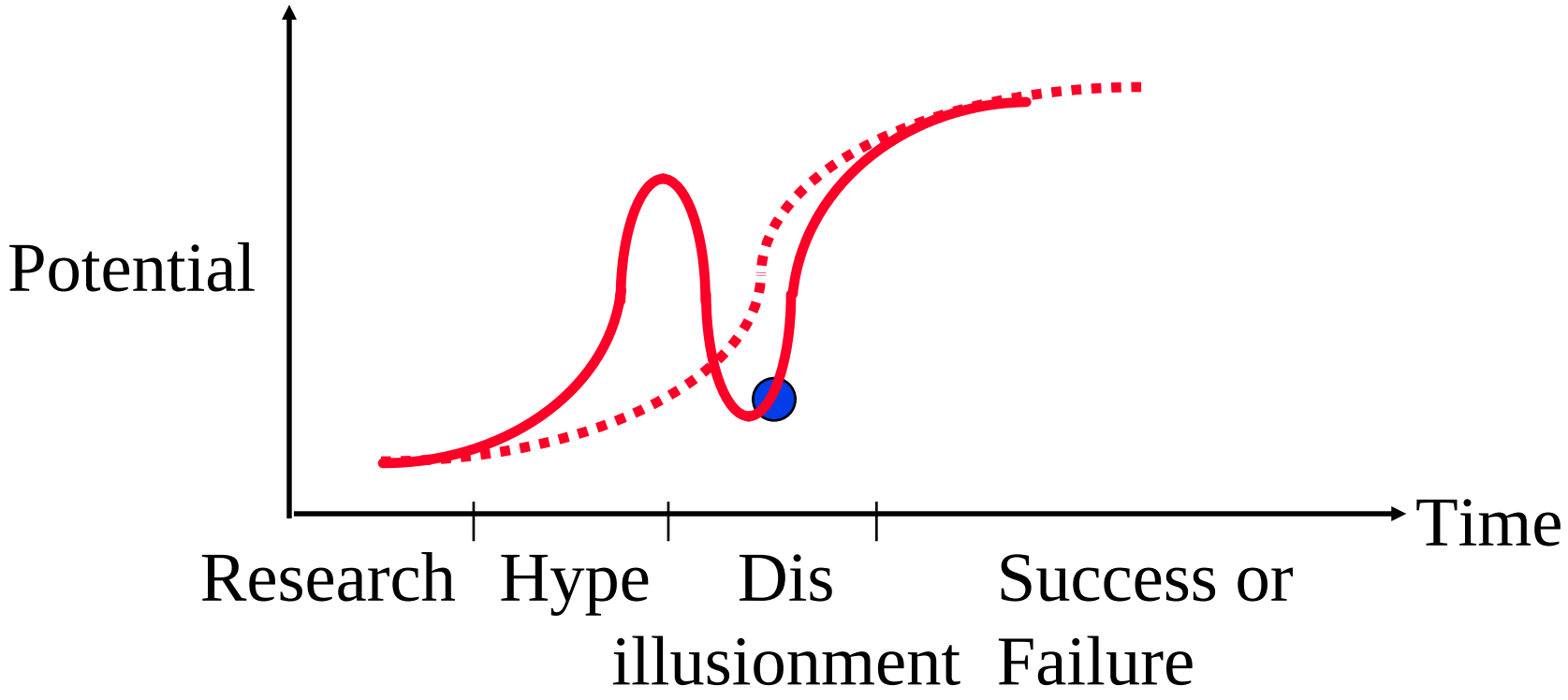
Impact of Networking

- Death of Time and Space ⇒ Globalization
- High data rate ⇒ Short product life cycles
- Long term = 1_2 year or 10_2 years at most
- Distance between research and products has narrowed
- 3-6 years PhD research ⇒ Topic out-of-date by graduation
- New Opportunities/Challenges for educators (globalization)
- New challenges for learners (Immediacy)
- A handheld device has enough storage to carry a small library
- Computers have bigger memory than humans
  ⇒ Knowing where to find the information is more important than the information
- Web ⇒ Information production and dissemination costs = zero
  ⇒ Too much (mis) information = Needles in the haystack

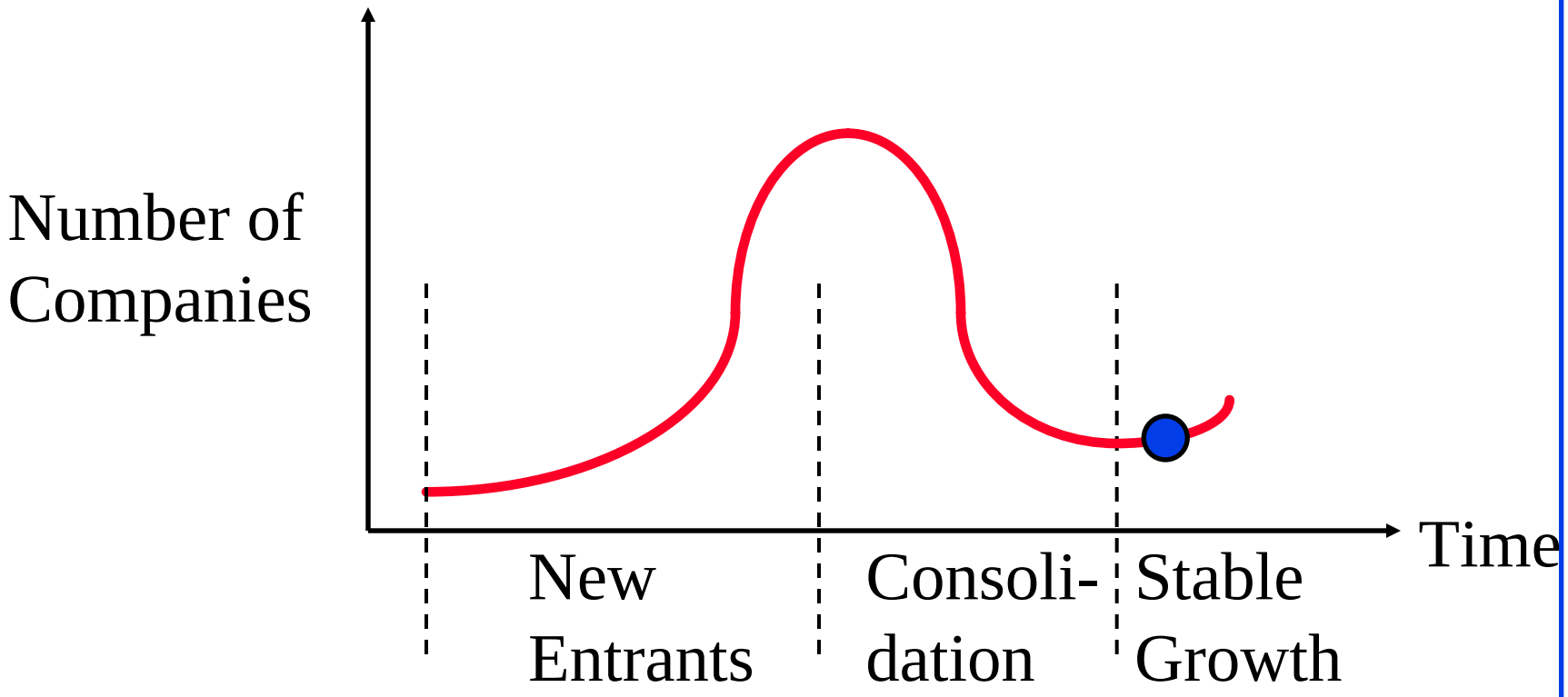
Life Cycles of Technologies



Hype Cycles of Technologies



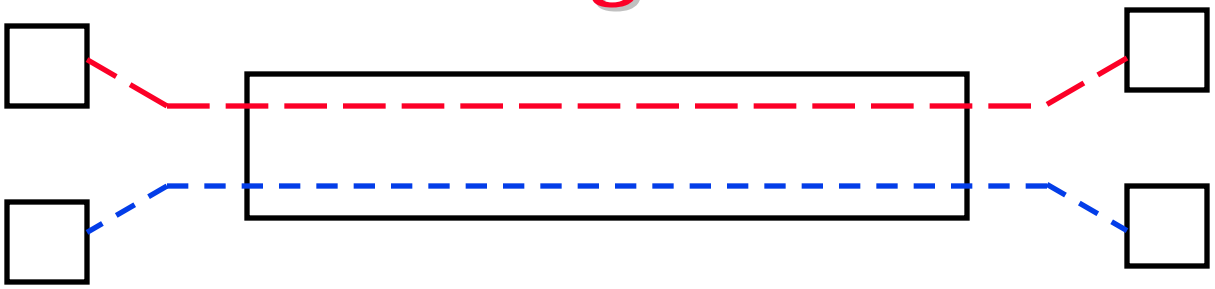
Industry Growth

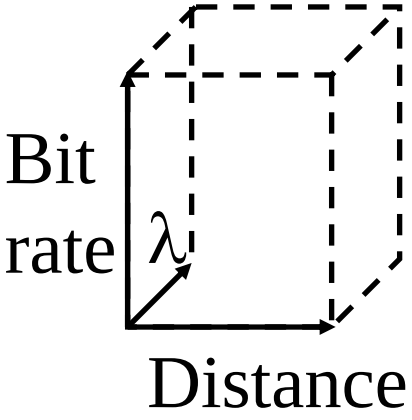


Top 10 Developments of 2004

- Large investments in Security
- WiFi is spreading (Intel Centrino)
- Broadband Access is growing faster than cell phones
- Fiber is creeping towards home
- Voice over IP (VOIP) is in the Mainstream
- Digital media (Video and Music) in the family room
- Multi-service IP: Voice, Video, and Data
- Multimedia (Video and images) over wireless
- MPLS for traffic engineering and QoS
- Ethernet end-to-end

Dense Wavelength Division Multiplexing





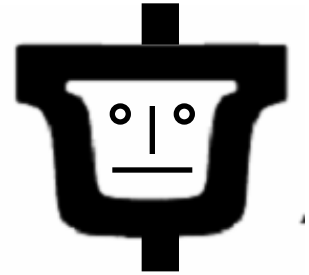
- 7λ× 200 Gbps (NTT'97)
- 19λ× 160 Gbps (NTT'99)
- 160λ× 20 Gbps (NEC'00)
- 128λ× 40 Gbps to 300 km (Alcatel'00)
- 1λ×1200 Gbps to 70 km using TDM (NTT'00)
- 64λ× 40 Gbps to 4000 km (Lucent'02)
- Theoretically 1022 Wavelengths on one fiber (Lucent'99)
- Potential: 58 THz = 50 Tbps on 10,000 λ's
- Ref: Optical Fiber Conference (OFC) 200x.

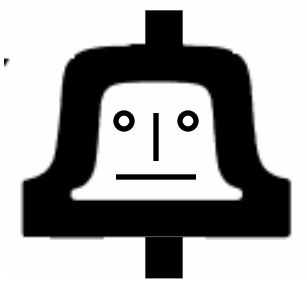
Core Optical Networks

- Higher Speed: 10 Gbps to 40 Gbps[1]
- Longer Distances: 600 km to 6000 km
- More Wavelengths: 16 λ's to 160 λ's
- All-optical Switching: OOO vs OEO Switching

- [1]May 25, 2004: MCI 40 Gbps between two IP routers in San Francisco and San Jose, http://biz.yahoo.com/prnews/040525/dctu050_1.html

Ethernet: 1G vs 10G Designs





1G Ethernet	10G Ethernet
❑ 1000 / ~~800~~ / ~~622~~ Mbps **Single** data rate	❑ 10.0/9.5 Gbps **Both** rates.
❑ **LAN** distances only	❑ LAN and **MAN** distances
❑ No Full-duplex only ⇒ **Shared** Mode	❑ Full-duplex only ⇒ **No Shared** Mode
❑ Changes to **CSMA/CD**	❑ **No CSMA/CD** protocol ⇒ No distance limit due to MAC ⇒ Ethernet End-to-End

Enterprise vs Carrier Ethernet

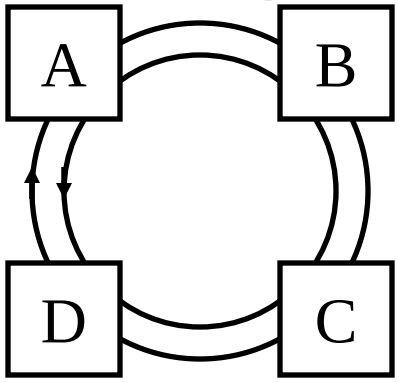
Enterprise

- Distance: up to 2km
- Scale:
  - Few K MAC addresses
  - 4096 VLANs
- Protection: Spanning tree
- Path determined by spanning tree
- Simple service
- Priority ⇒ Aggregate QoS
- No performance/Error monitoring (OAM)

Carrier

- Up to 100 km
- Millions of MAC Addresses
- Millions of VLANs
  Q-in-Q
- Rapid spanning tree
  (Gives 1s, need 50ms)
- Traffic engineered path
- SLA
- Need per-flow QoS
- Need performance/BER

RPR: Key Features



- Dual Ring topology
- Supports broadcast and multicast
- Packet based ⇒ Continuous bandwidth granularity
- Max 256 nodes per ring
- MAN distances: Several hundred kilometers.
- Gbps speeds: Up to 10 Gbps
- Too many features and alternatives too soon (702 pages)

Networking: Failures vs Successes

- 1980: Broadband (vs baseband)
- 1984: ISDN (vs Modems)
- 1986: MAP/TOP (vs Ethernet)
- 1988: OSI (vs TCP/IP)
- 1991: 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 ⇒ Evolution
- High Performance
- Killer Applications
- Timely completion
- Manageability
- Interoperability
- Coexistence with legacy LANs
  Existing infrastructure is more important than new technology

Access Networks

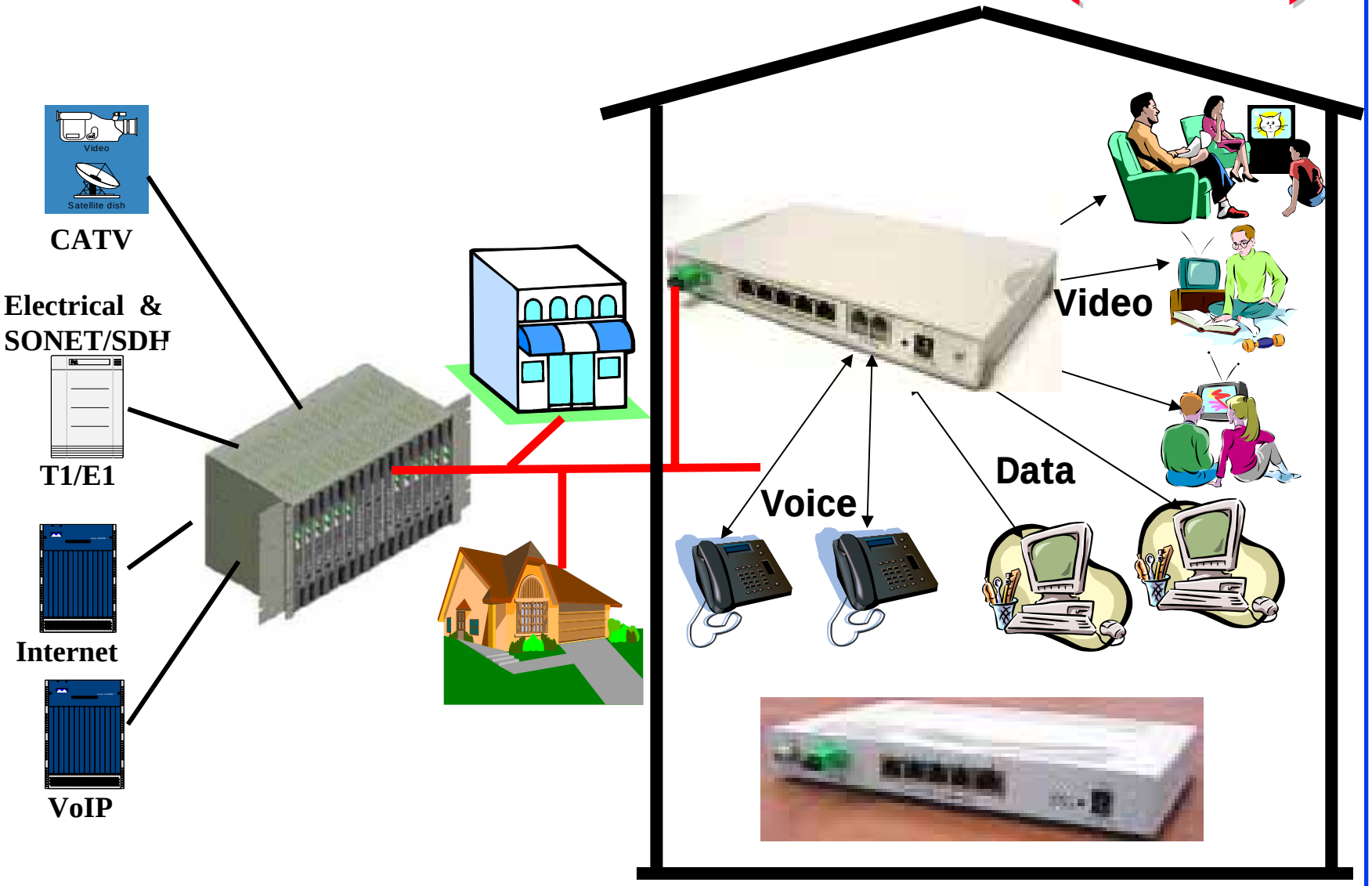
- 63.84 M DSL subscribers worldwide. 2003 growth rate of 77.8% is more than the peak growth rate of cellular phones.
- All countries are racing to a leadership position in broadband
- Digital-Divide ⇒ 30M subs@10Mbps, 10M@100Mbps in Japan by 2005
- Telecom epicenter has moved from NA+Europe to Asia Pacific

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

Fiber to the Home (FTTH)

- DSL data rate decreases with distance. Max 5.5kms.
  $\Rightarrow$ Rural areas not reachable directly by copper $\Rightarrow$ FTTN
- Global Competition $\Rightarrow$ National initiatives:
  - According to SCTE (2004) there will be 14.4M FTTH subscribers worldwide by 2008 from 800,000 in 2004
  - Japan (clear leader; 530,000 homes with fiber out of 600,000 as of July, 03) (source: FTTH Council 10-03)
  - Korea, Canada, Sweden, China, Holland, Germany, UK, France, Australia, US beginning to move in the direction
- Fiber prices have come down drastically ($200 to $500/Subscriber) to similar levels as DSL
- Over 800 Communities in USA are investigating FTTH
- US FCC ruling of removing restrictions from RBOCs FTTH
- Verizon and Bellsouth announced to pass 1M homes each in 04.

Ethernet to the First Mile (EFM)

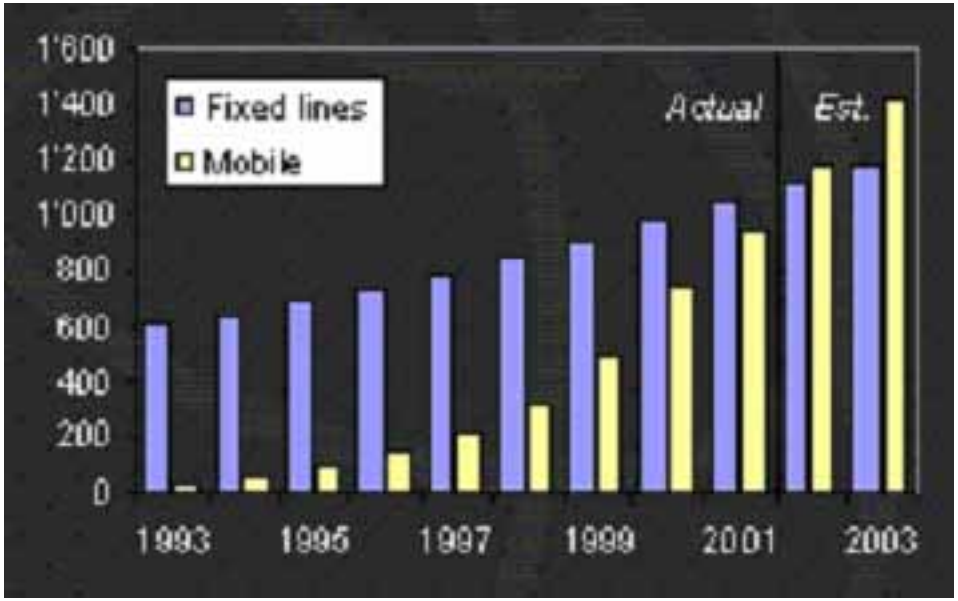


Wireless Issues

- Security (IEEE 802.11i)
- Higher Data rate (IEEE 802.3n, 100 Mbps, using Multiple-input multiple-output antennae)
- Longer distance (WiMAX, >1Mbps to 50 km)
- Seamless Networking ⇒ Handoff (IEEE 802.21)
- Mobility (IEEE 802.20)
- Large scale networks (RFID, Sensors)

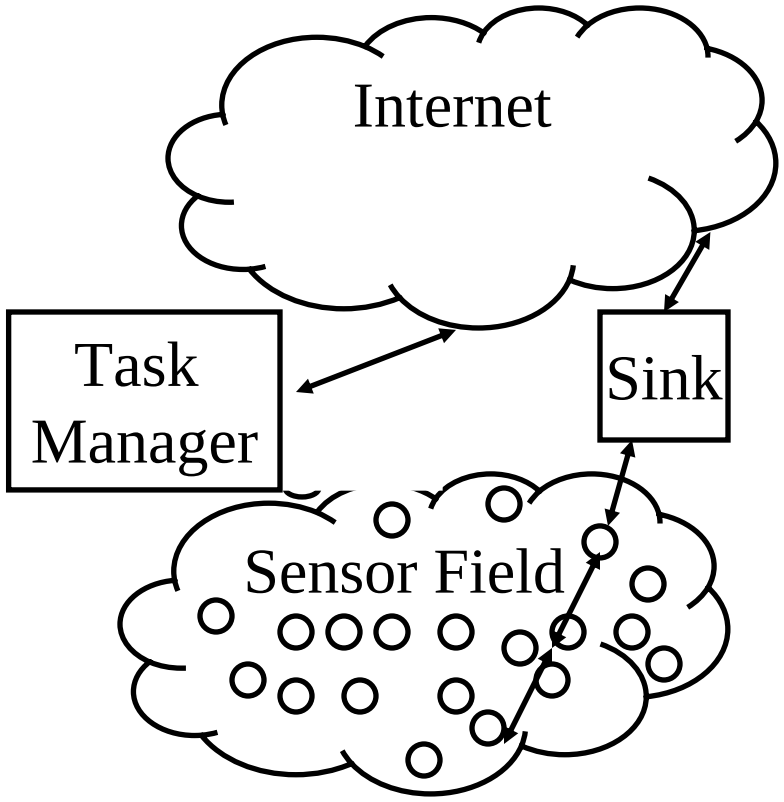
Mobility

- 1.35 Billion Mobile subscribers vs 1.2 Billion Fixed line subscribers at the end of 2003 [ITU]
- 70% of internet users in Japan have mobile access
- Vehicular mobility up to 250 Km/h (IEEE 802.20)

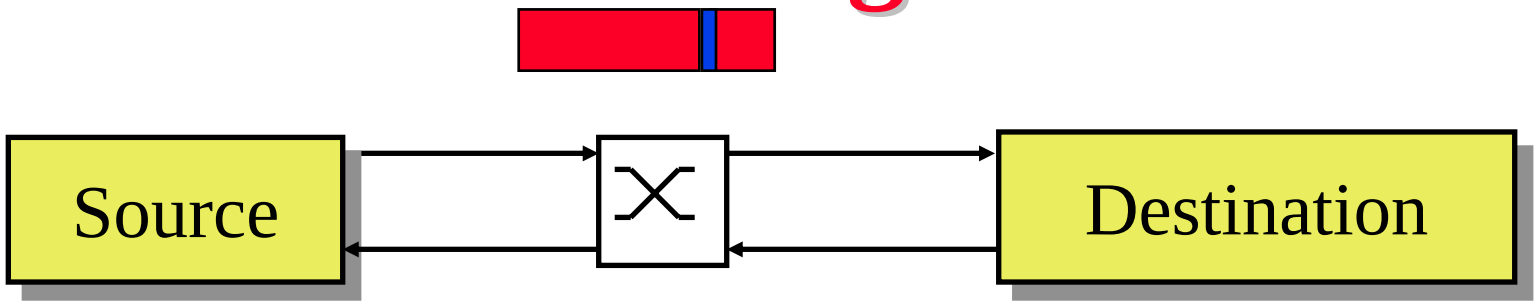


Sensor Networks

- A large number of **low-cost**, **low-power**, **multifunctional**, and small sensor nodes consisting of sensing, data processing, and communicating components
- Key Issues:
  1. Scalability
  2. Power consumption
  3. Fault tolerance
  4. Network topology
  5. Transmission media
  6. Cost
  7. Operating environment
  8. Hardware constraints



Traffic Management

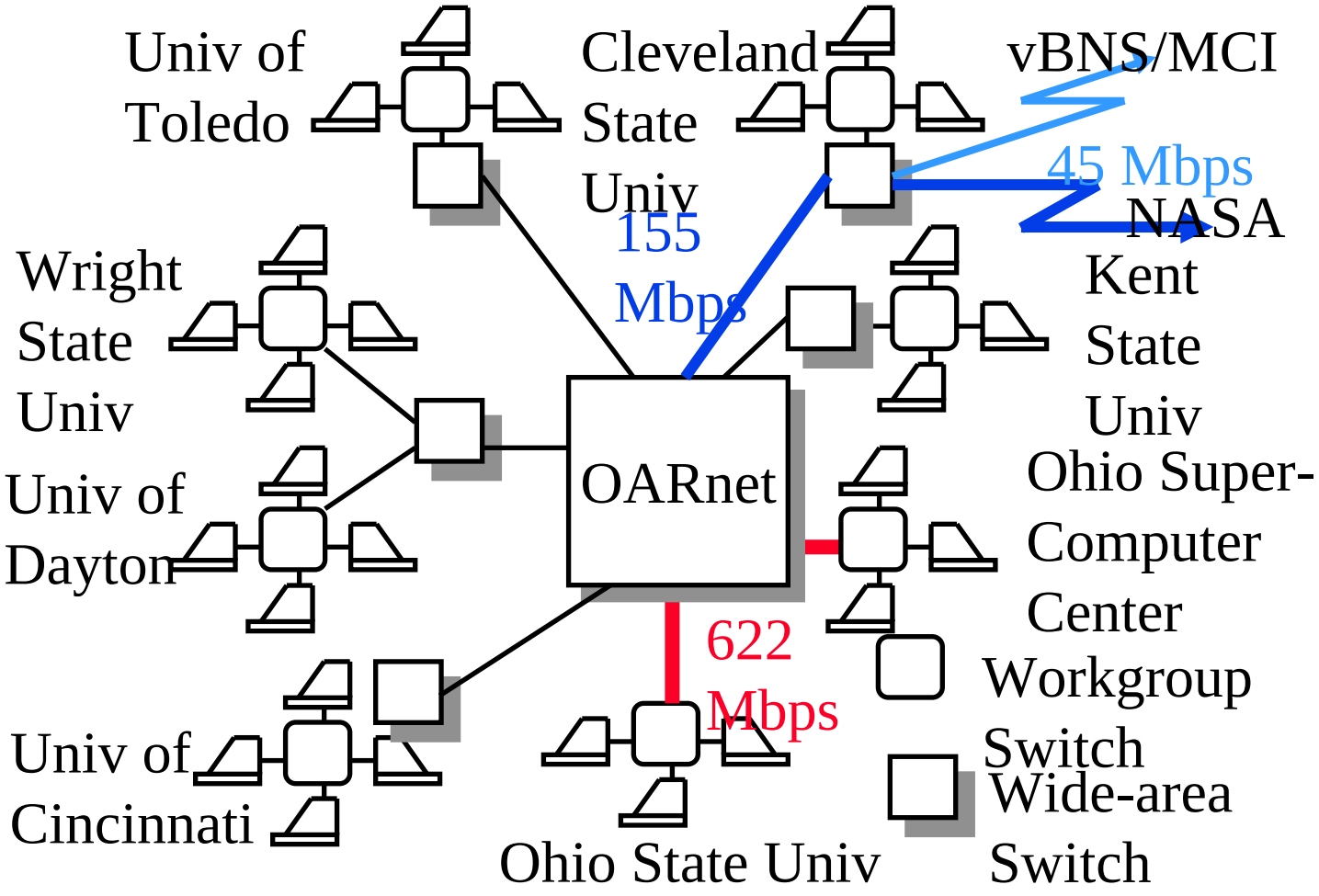


Change rate to 12.3 Mbps

- DECbit scheme: One Bit in the header ⇒ Go up/Down
  - Used now in Frame Relay (FECN)
  - Used in ATM (EFCI)
  - Slow-start in TCP/IP (Additive Increase, Multiplicative decrease)
  - Explicit Congestion Notification (ECN) in TCP/IP
- In July 1994, we proposed Explicit Rate Approach for ATM/ABR. 100+ Contribution. Current standard.
- Thirteen patents. Collaboration with industry.

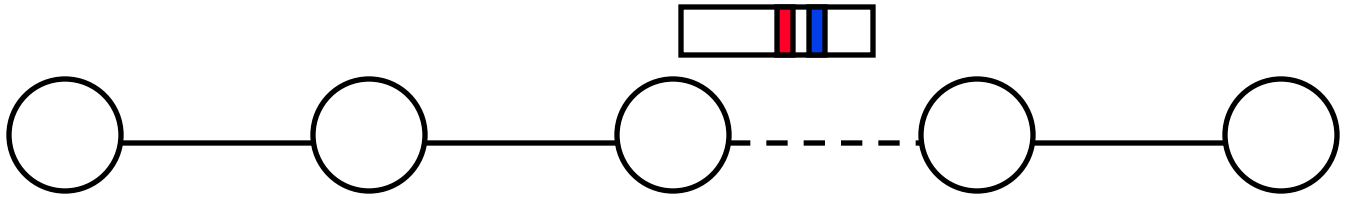
OCARnet

- Ohio Computing and ATM Research Network ($1.7M+)



Wireless Networking

- "An Experimental Testbed for Research in Advanced Wireless Communications," $1.5M from NSF
- In collaboration with EE Dept experts in Antenna design
- Dynamically adapt to measured error characteristics:
  - Media Access Protocol
  - Transport protocol (retransmissions)
  - Hand-off strategies
- Modem design for optimal higher-layer performance
- Use two ECN bits and congestion *coherence* to distinguish errors and congestion in wireless networks



Collaboration

- **Inter-Faculty**: Joint funding with other faculty in the dept: Wu-Chi, Steve Lai, D. Panda, A. Arora
- **Inter-Department**: Joint funding with other Depts.: EE (Stan Ahalt, Jennifer Hoe, Yuan Zhang, Mike Fitz), OSC (Al Stutz), OARnet (Doug Gale, Eugene Wallis)
- **Inter-University**: OCARnet, ODEN
- **With Industry**:
  - Joint research proposals with Nokia, ...
  - Research Sponsored by: NASA, FORE, Nokia, ...
  - New Technology Seminars at Nortel, Lucent, ...
- **Industry Forums**: IETF, ATM Forum, TIA, IEEE, Networld+Interop

Top Networking Research Topics

1. Security
2. Large scale wireless networks (RFID, Sensors)
3. Mobility
4. High-Speed wireless
5. Optical packet switching
6. Network-based computing (Grid computing)

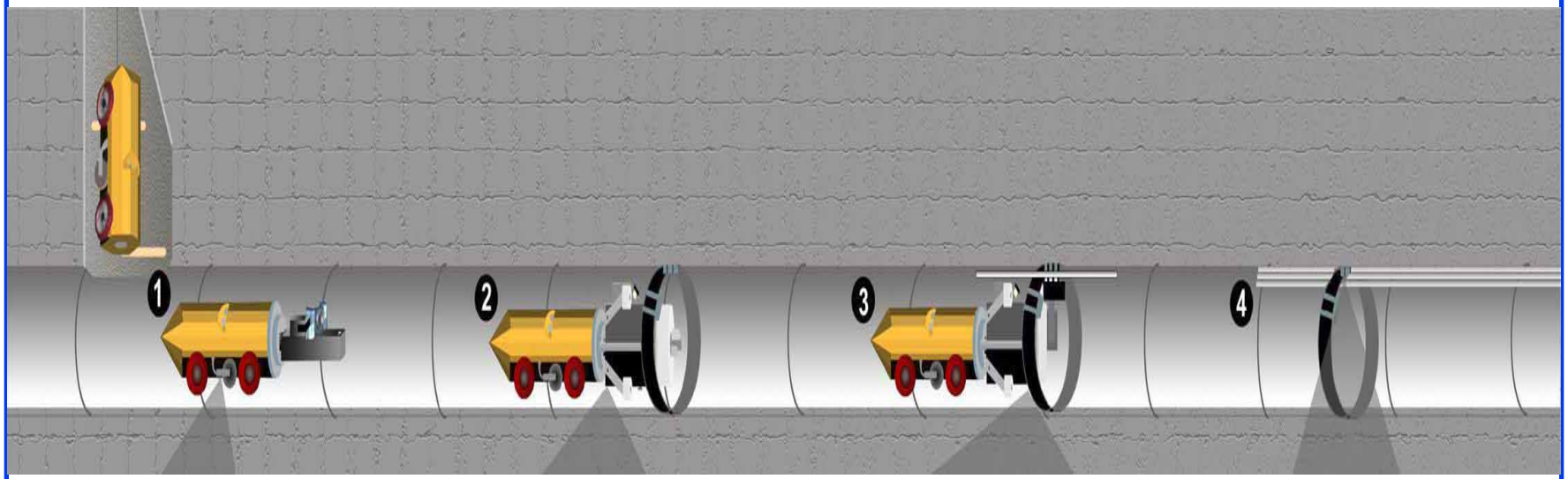
Recent Funding Opportunities

- $40M from NSF on networking research. Two focus areas:
  - Programmable wireless networks
  - Networking of sensor systems
- NIST SBIR:
  - S/w Tools For IEEE 1451-Based Smart Sensor Networks
  - Secure Ad Hoc Wireless Networks
- DOE $400M
  - Massively parallel computing
  - Lightweight operating systems for parallel computers
- DARPA:
  - Internet Control Plane
  - All-optical Packet Router $18M

Fiber Access Thru Sewer Tubes (FAST)

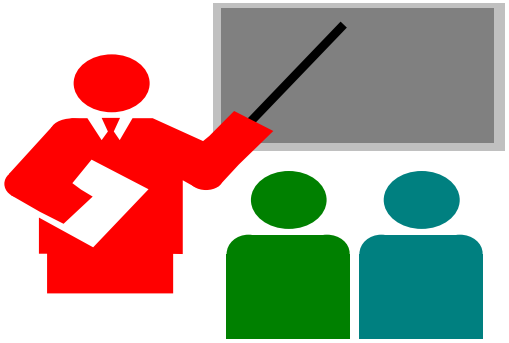
- Right of ways is difficult in dense urban areas
- Sewer Network: Completely connected system of pipes connecting every home and office
- Municipal Governments find it easier and more profitable to let you use sewer than dig street
- Installed in Zurich, Omaha, Albuquerque, Indianapolis, Vienna, Ft 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. Collapse of Space and Time
   $\Rightarrow$ Global competition and opportunities
2. Hype Cycles of Technologies
   $\Rightarrow$ Recovering from the bottom
3. Core market stagnant. Metro and Access more important.
4. SONET vs Ethernet in Metro. Need carrier grade Ethernet.
5. Low cost is the key to success of a technology
6. FTTH is finally happening. EPON will lead.
7. Key issues in Wireless are Security and Mobility

Networking Trends: References

- References on Networking Trends, http://www.cis.ohio-state.edu/~jain/refs/ref_trnd.htm
- References on Optical Networking, http://www.cis.ohio-state.edu/~jain/refs/opt_refs.htm
- References on Residential Broadband, http://www.cis.ohio-state.edu/~jain/refs/rbb_refs.htm
- References on Wireless Networking, http://www.cis.ohio-state.edu/~jain/refs/wir_refs.htm