Computer Networking: Recent Developments, Trends, and Issues

Raj Jain

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Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/

http:/www.cse.ohio-state.edu/~jain/talks/duke0502.htm

This on-line version of the presentation does not include the cartoons used during the presentation

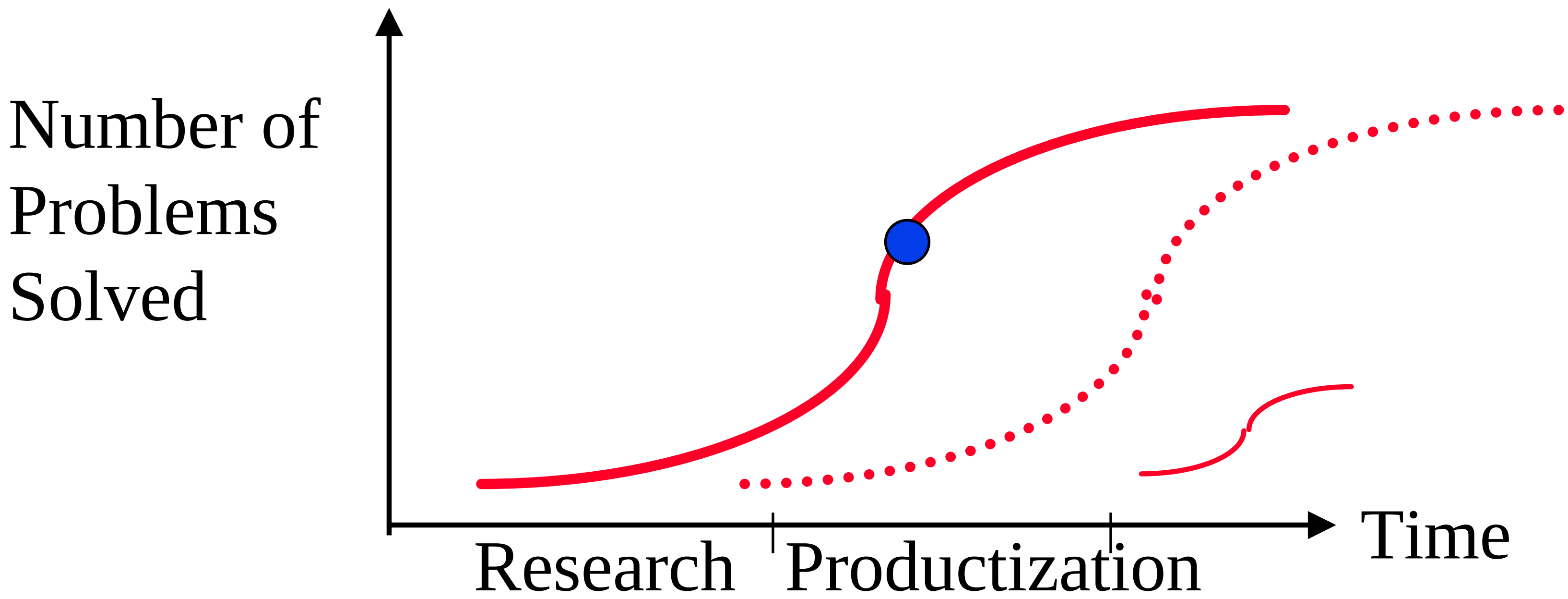
NAYNA Networks

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

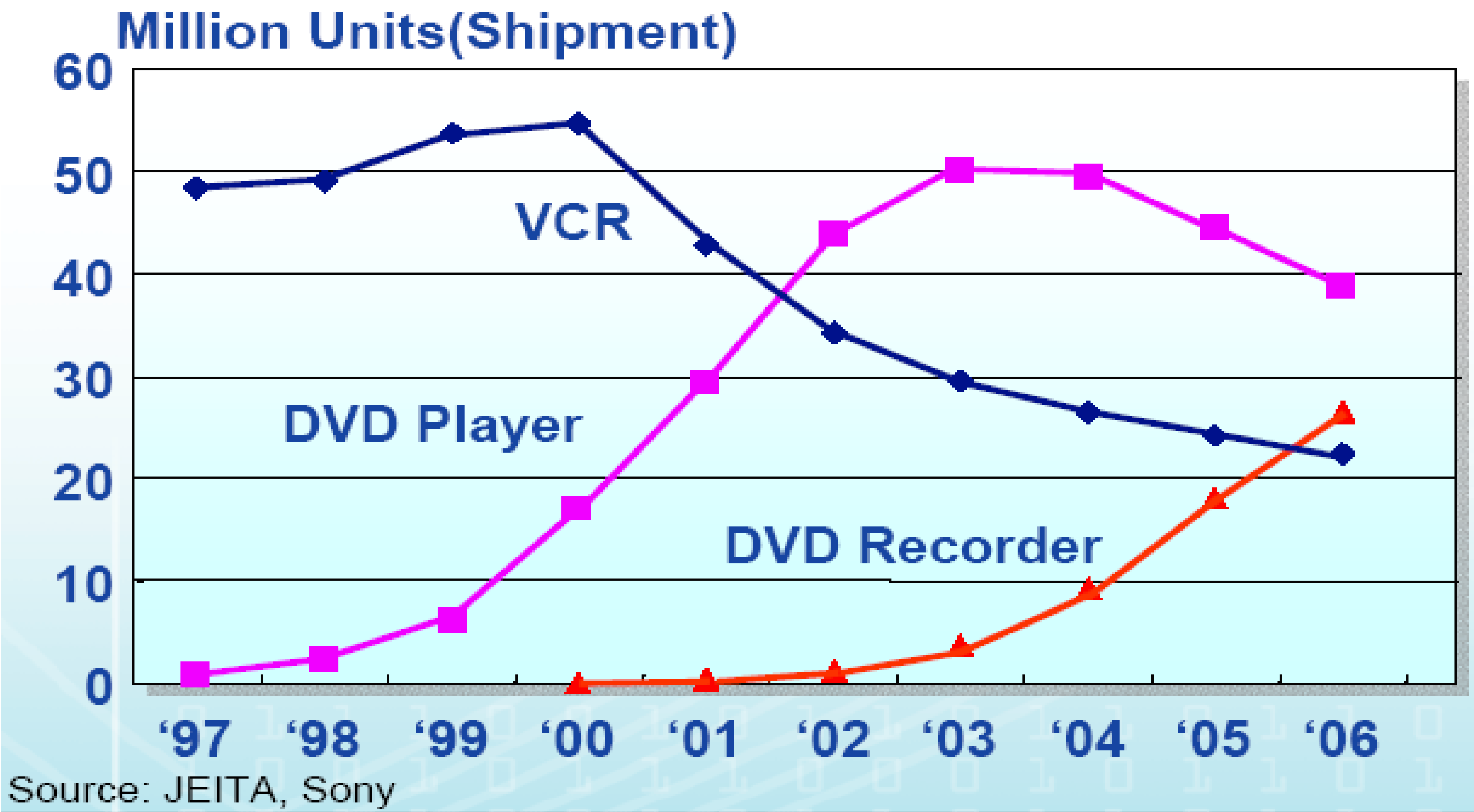
Trend: Back to ILECs

1. CLECs to ILECs
   ILEC: Slow, steady, predictable.
   CLEC: Aggressive, Need to build up fast
   New networks with newest technology
   No legacy issues
2. Back to Voice
   CLECs wanted to *start* with data
   ILECs want to *migrate* to data
   ⇒ Equipment that support voice circuits but allow packet based (hybrids) are more important than those that allow only packet based

Life Cycles of Technologies

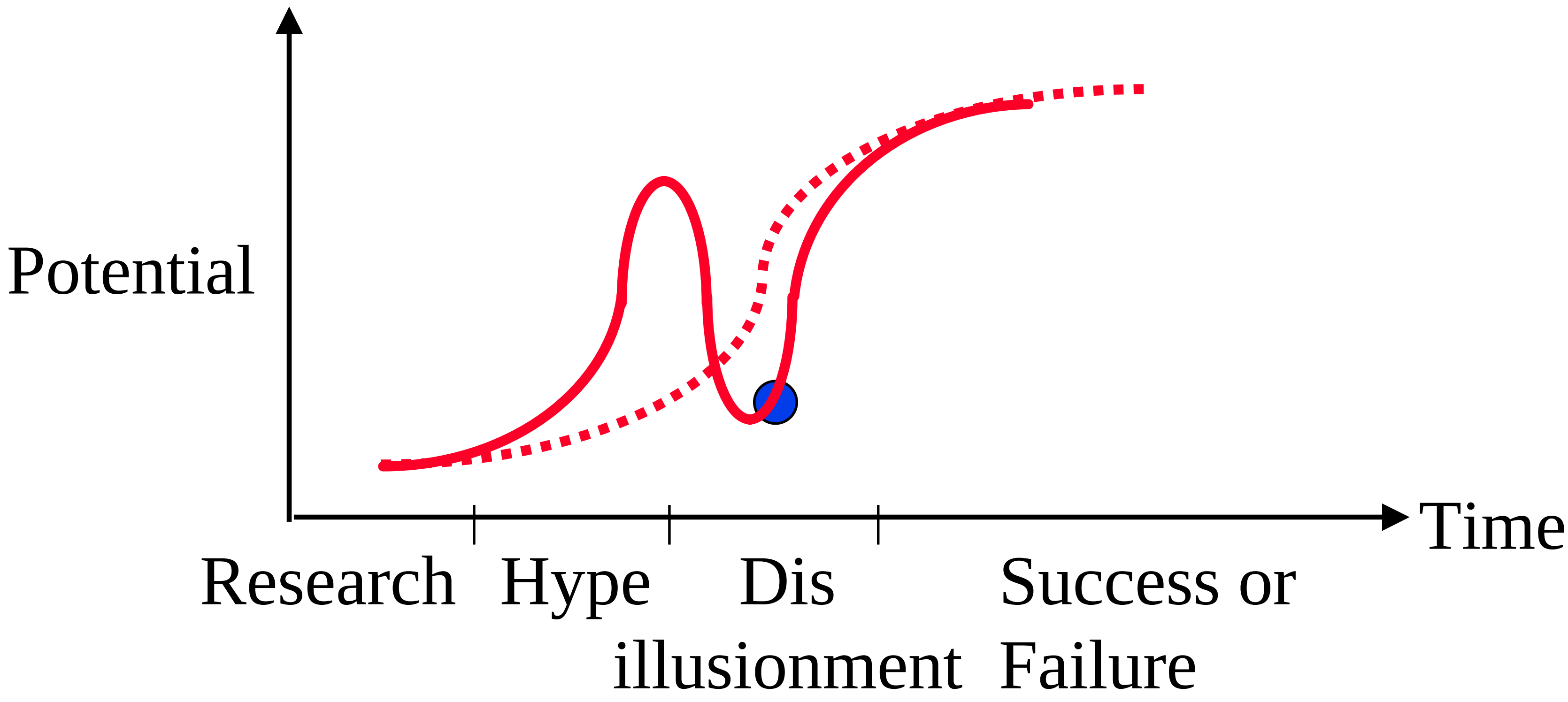


VCR vs DVD

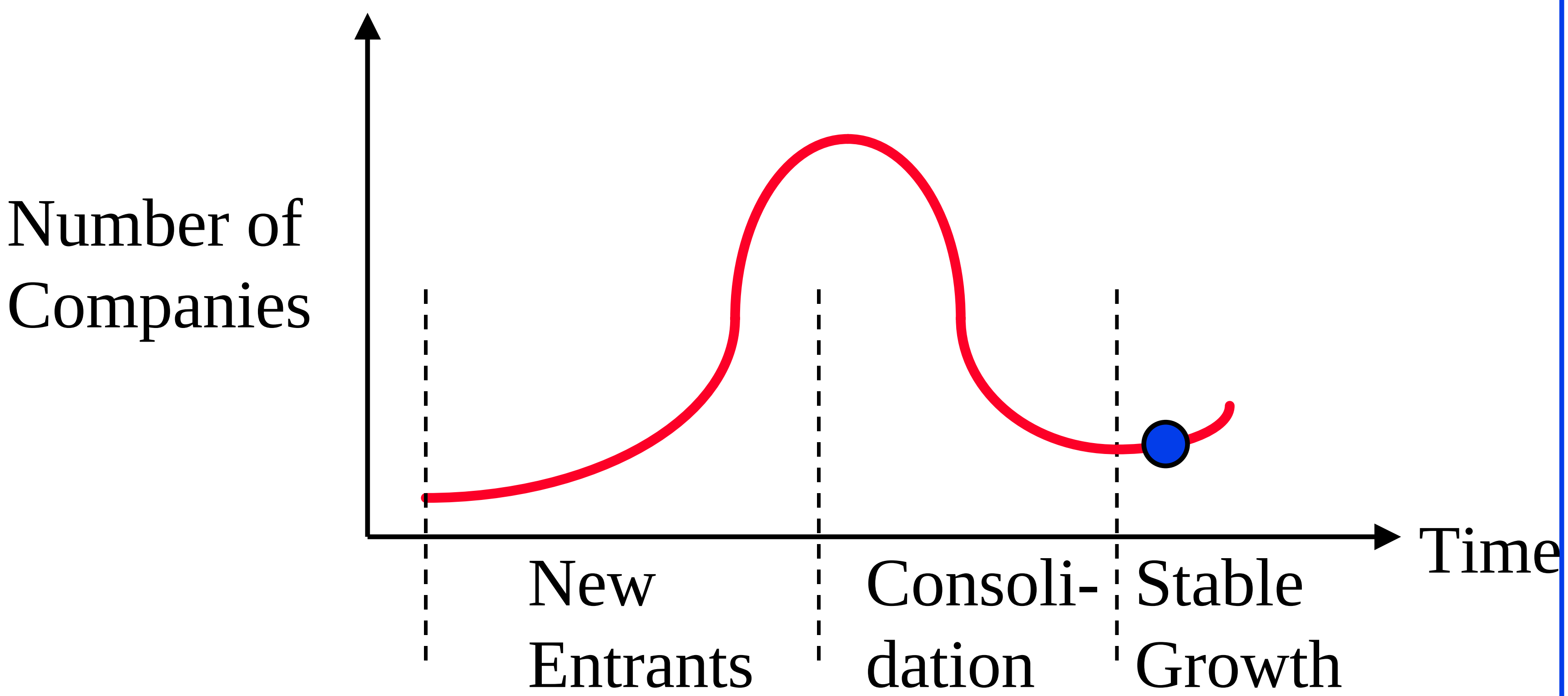


Million Units(Shipment)
60
50
40
30
20
10
0
VCR
DVD Player
DVD Recorder
'97
'98
'99
'00
'01
'02
'03
'04
'05
'06
Source: JEITA, Sony

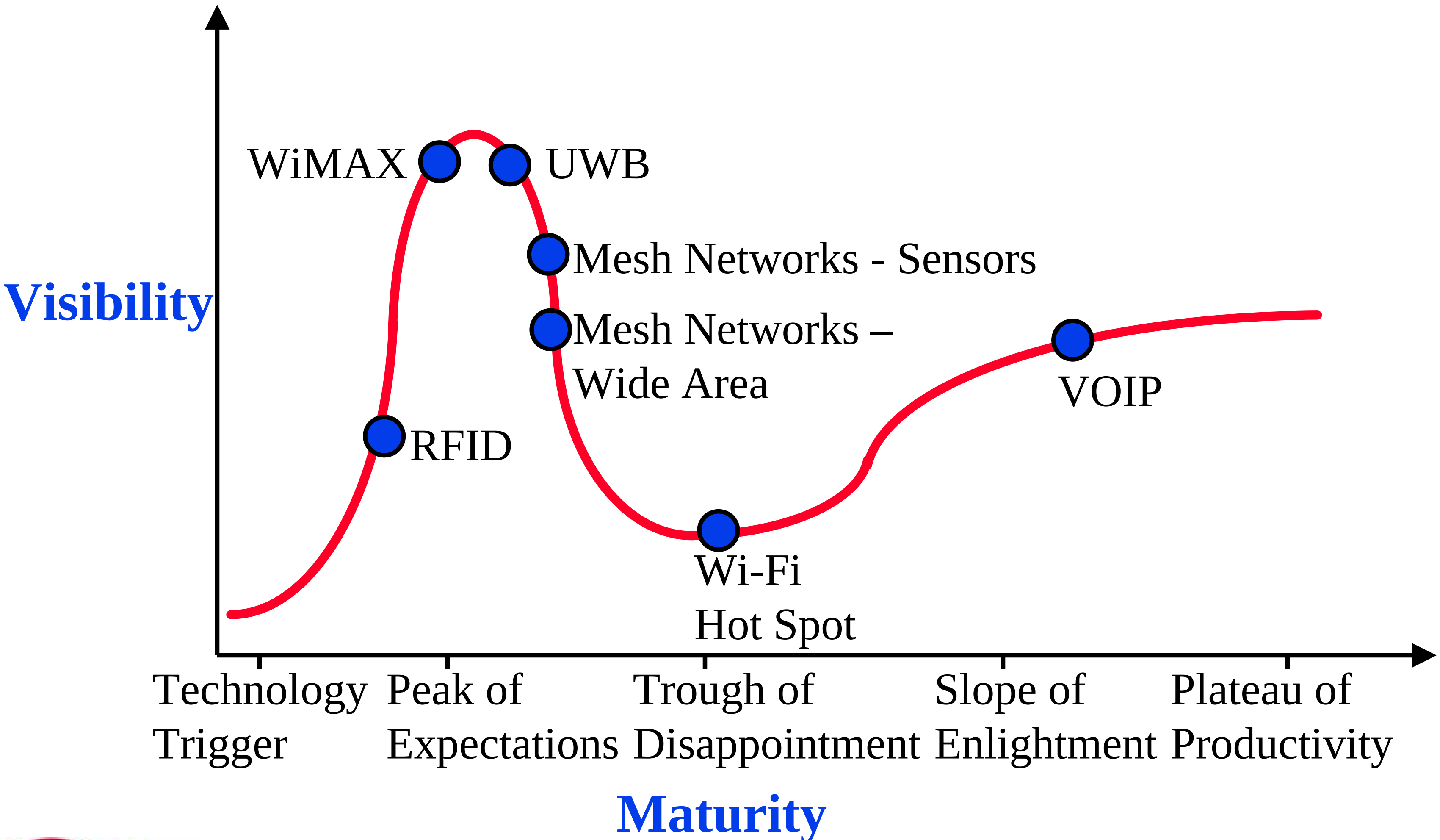
Hype Cycles of Technologies



Industry Growth



Hype Cycle 2004

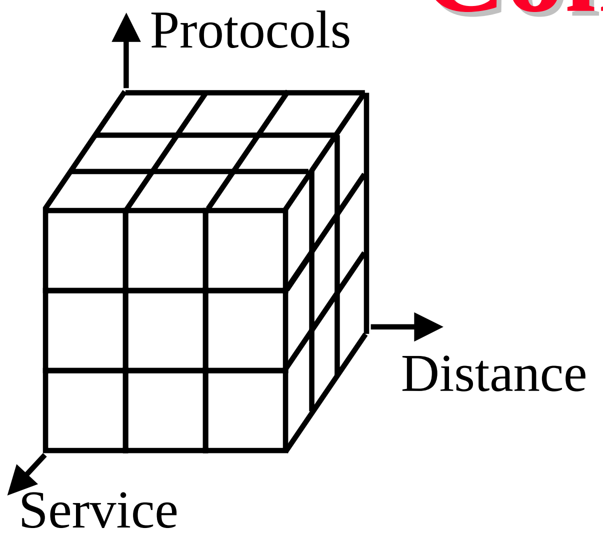


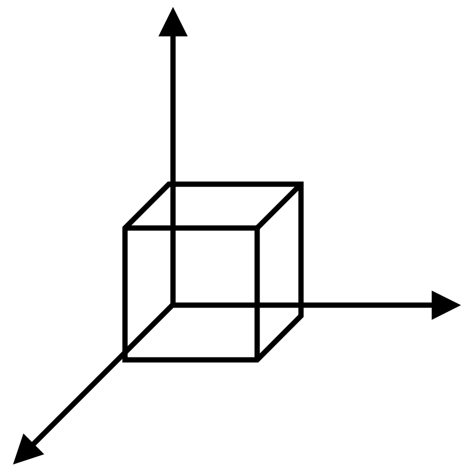
Based on Gartner Research (July 2004)

Top 10 Developments of 2004

1. Large investments in Security
2. Wireless (WiFi) is spreading (Intel Centrino)
3. More Cell phones than POTS.
   Smart Cell phones w PDA, email, video, images ⇒ Mobility
4. Broadband Access is growing faster than cell phones
5. Fiber is creeping towards home
6. Ethernet extending from Enterprise to Access to Metro …
7. Wiring more expensive than equipment ⇒ Wireless Access
8. Multi-Protocol Label Switching for traffic engineering
9. Voice over Internet Protocol (VOIP) is in the Mainstream
10. Multi-service IP: Voice, Video, and Data

Convergence





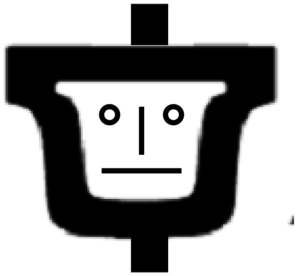
- Distance: LAN vs MAN
- Services: Data, Voice, Video
- Phy: Circuit switched vs Packet switched
- L2 Protocols: Ethernet and SONET
- L3 Protocols: IP
- HTTP: Hyper-Application Access protocol

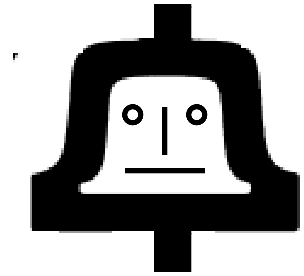
Core Networks

- Higher Speed/λ: 10 Gbps to 40 Gbps to 160 Gbps
- Longer Distances/Regens: 600 km to 6000 km
- More Wavelengths: 16 λ's to 160 λ's

- 1 Fiber = 160 λ x 40 Gbps = 6.4 Tbps
  = 1 kbps x 6 Billion = 1 kbps/person

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

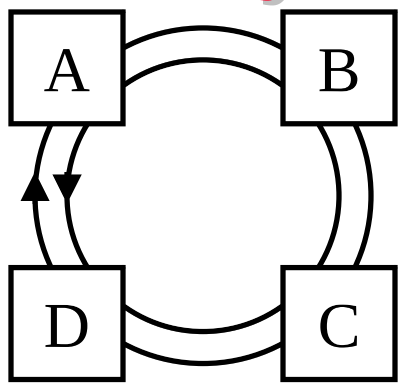
- 10.0/9.5 Gbps
  Both rates.
- LAN and **MAN** distances
- Full-duplex only
  ⇒ **No Shared** Mode
- **No CSMA/CD** protocol
  ⇒ No distance limit due to MAC
  ⇒ *Ethernet* End-to-End

Enterprise vs Carrier Ethernet

Enterprise	Carrier
Distance: up to 2km	Up to 100 km
Scale:	
Few K MAC addresses	Millions of MAC Addresses
4096 VLANs	Millions of VLANs Q-in-Q
Protection: Spanning tree	Rapid spanning tree (Gives 1s, need 50ms)
Path determined by spanning tree	Traffic engineered path
Simple service	SLA. Rate Control.
Priority ⇒ Aggregate QoS	Need per-flow QoS
No performance/Error monitoring (OAM)	Need performance/BER

No 100 Mbps Ethernet switches with Q-in-Q, Rate control, Priority

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) 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)

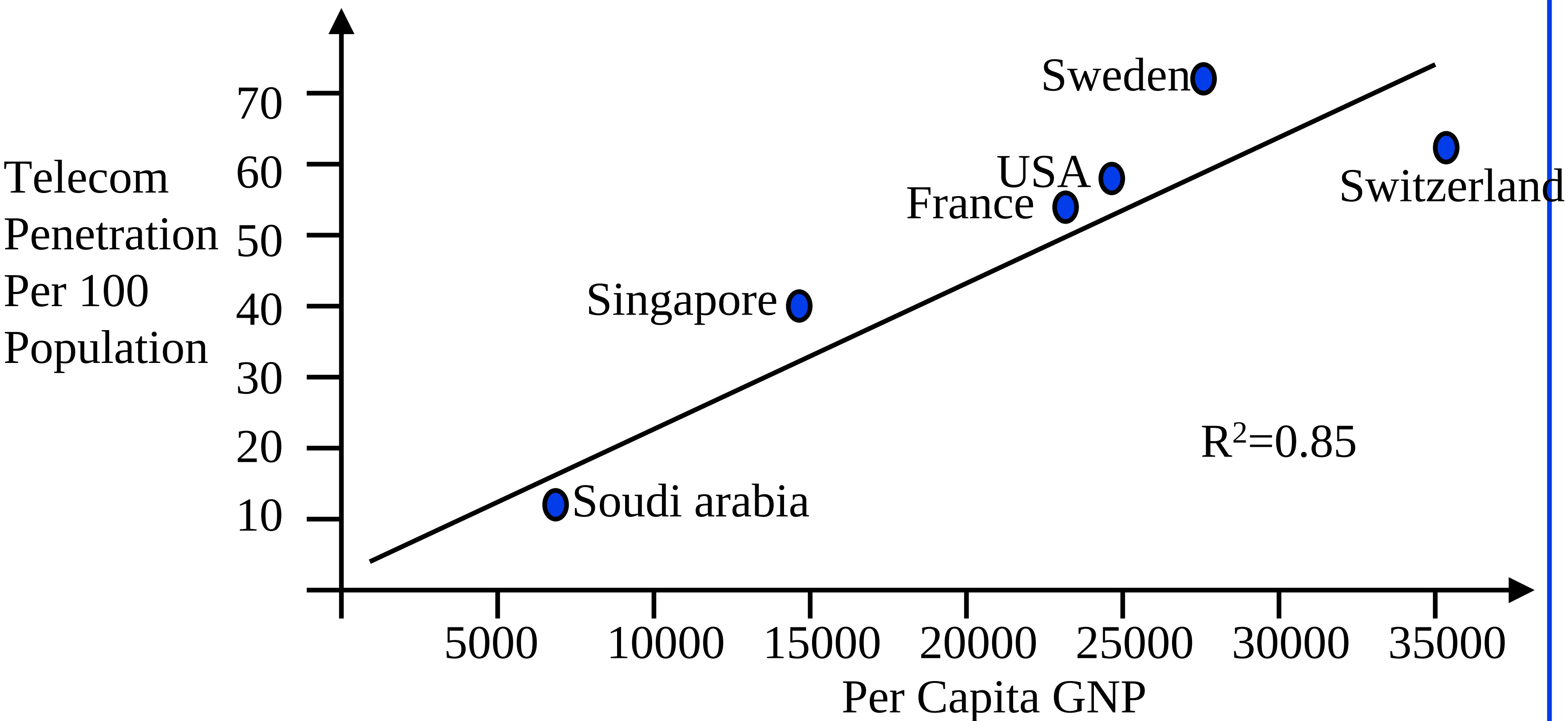
Requirements for Success

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

Laws of Networking Evolution

1. Existing infrastructure is more important then deploying new technology
   - Ethernet vs ATM, IP vs ATM
   - Exception: Killer technology, immediate savings
2. Modifying existing protocol is more acceptable than new protocols
   - TCP vs XTP
   - Exception: New applications (VOIP – SIP, MEGACO, …)
3. Traffic increases by a factor of X/year
   Total revenue remains constant (or decreases)
   $\Rightarrow$ Price/bps goes down by $\cong$ X/year (X = 2 to 4)

Telecom and Economic Development



- Fundamental correlation between GDP growth and teledensity

Source: ITU

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 ⇒ 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

Japanese Fiber to Premises

PennWell

LIGHTWAVE

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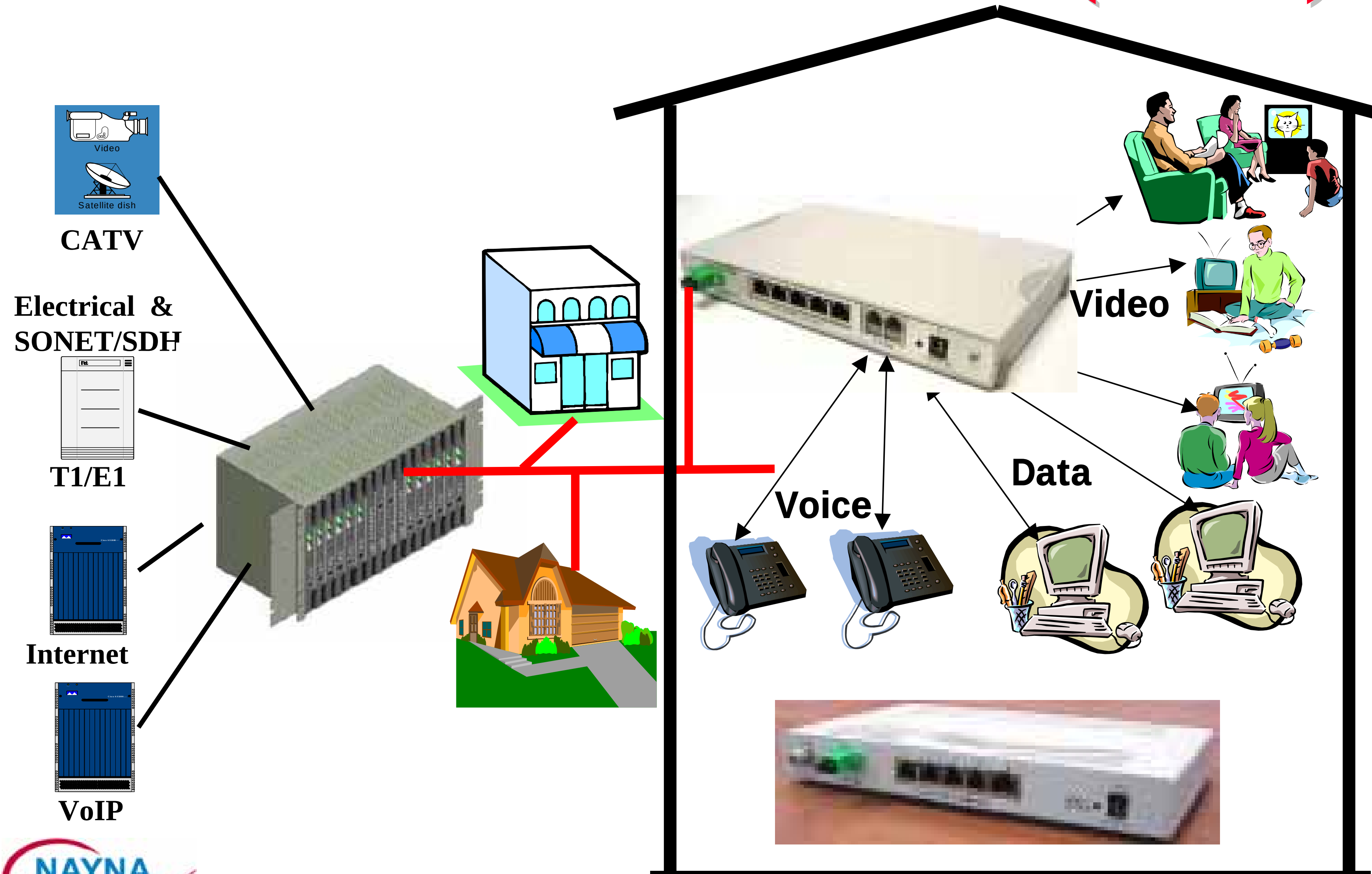
Japanese subscribers are adopting FTTH at a rate of 80,000-90,000 subscribers per month.

Japanese fiber to premises deployments worth watching

Meghan Fuller

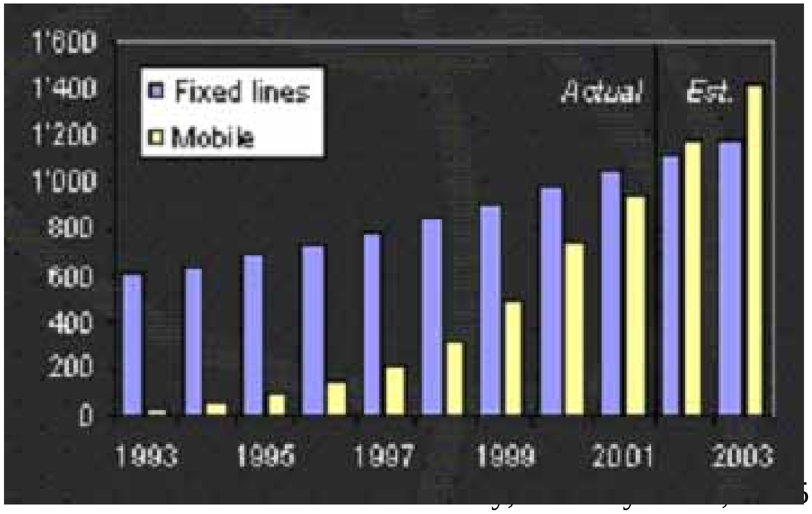
Japan represents the largest-and to date most successful-wide-scale fiber to the home (FTTH) deployment in the world. According to Hiroshi Ishikawa, president and CEO of NTT Advanced Technology, the R&D arm of NTT East and West, 50% of Japanese households have fiber service directly to the home. Thanks to a competitive marketplace and supportive government policies, broadband service in Japan is the cheapest in the world, at 18¢ per 100 kbits/sec (compared to $2.86 in the United States and $7.18 in the United Kingdom). Japanese subscribers are adopting FTTH at a rate of 80,000-90,000 subscribers per month. So what's next for Japan? And what can U.S. providers learn from Japan's aggressive FTTH deployment plans?

Ethernet to the First Mile (EFM)



Mobility

- 1.35 Billion mobile subscribers vs 1.2 Billion Fixed line subscribers at the end of 2003 [ITU]
- Number of wired phones in USA is declining for the first time since the Great Depression.
- 20% of world population is mobile. Need internet access. 70% of internet users in Japan have mobile access
- Vehicular mobility up to 250 Km/h (IEEE 802.20)



NAYNA Networks

Wireless Industry Trends

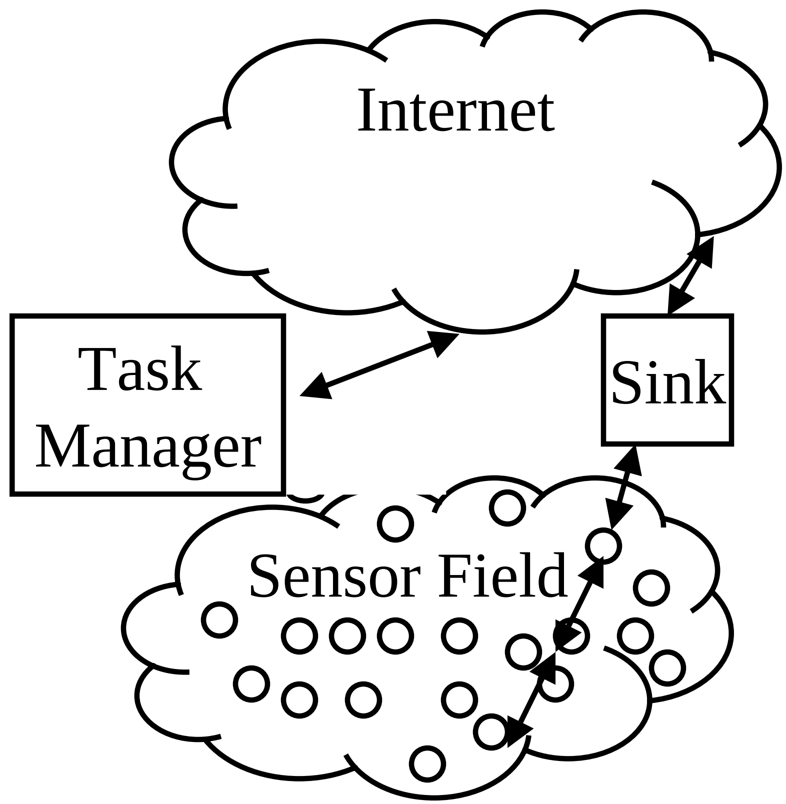
- Wireless industry is stronger than wireline. Particularly strong growth in developing countries.
- 48% of global telco revenues coming from wireless
- 26% of wireless revenues coming from data (vs voice)
- Past: Voice, email, SMS, Ring tones
- Present: Push, Gaming, Pictures, Instant Messaging
- Future: Music, Video, Location, Remote monitoring, m-commerce
- Long Term: Video telephony, remote enterprise applications, remote management, Multiparty collaboration,

Wireless Issues

- Security (IEEE 802.11i)
- Higher Data rate (IEEE 802.11n, 100 Mbps, using Multiple-input multiple-output antennas)
- Longer distance (WiMAX, >1Mbps to 50 km)
- Seamless Networking $\Rightarrow$ Handoff (IEEE 802.21)
- Mobility (IEEE 802.20)
- Automated RF management (Cell sites)
- Large scale networks (RFID, Sensors)

Sensor Networks

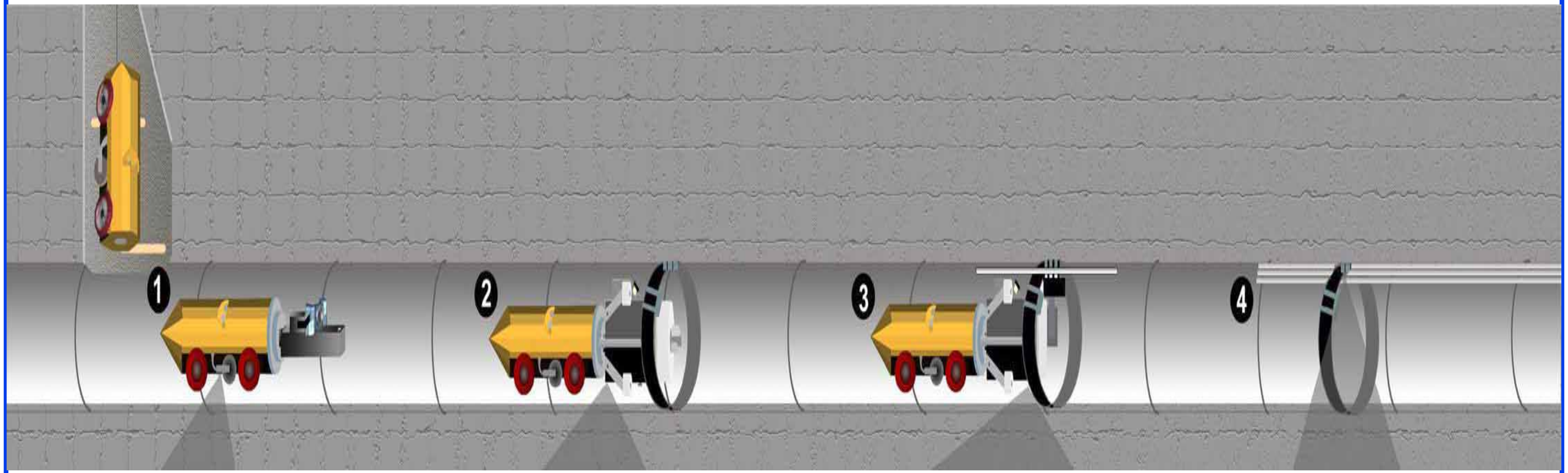
- A large number of **low-cost**, **low-power**, **multifunctional**, and small sensor nodes consisting of sensing, data processing, and communicating components
- Key Issues:
  1. Scalability
  2. Power consumption
  3. Fault tolerance
  4. Network topology
  5. Transmission media
  6. Cost
  7. Operating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



Fiber Access Thru Sewer Tubes (FAST)

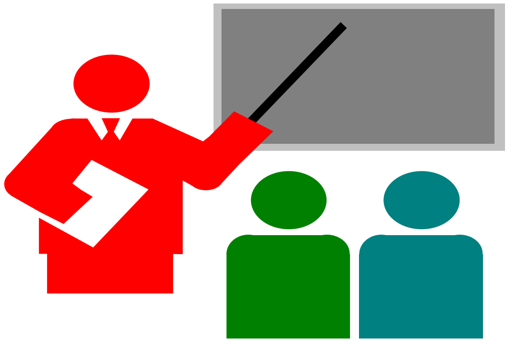
- Right of ways is difficult in dense urban areas
- Sewer Network: Completely connected system of pipes connecting every home and office
- Municipal Governments find it easier and more profitable to let you use sewer than dig street
- Installed in Zurich, Omaha, Albuquerque, Indianapolis, Vienna, Ft 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. Hype Cycles of Technologies
   ⇒ Recovering from the bottom
   Networking (infrastructure) are mature (widely deployed) technologies. Evolution is more like to succeed than revolution.
2. Enterprise networking is different from carrier networking. Core market stagnant. Metro and Access more important.
3. SONET vs Ethernet in Metro. Need carrier grade Ethernet.
4. Low cost is the key to success of a technology
5. FTTH is finally happening. EPON will lead.
6. 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