Computer Networking: Recent Developments, Trends, and Issues

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1. Life Cycle of Technologies
2. Top 10 Developments of 2004
3. Optical Networking Developments: Core, Metro, Access
4. Networking Technologies: Failures vs Successes
5. Wireless Networking: Issues

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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

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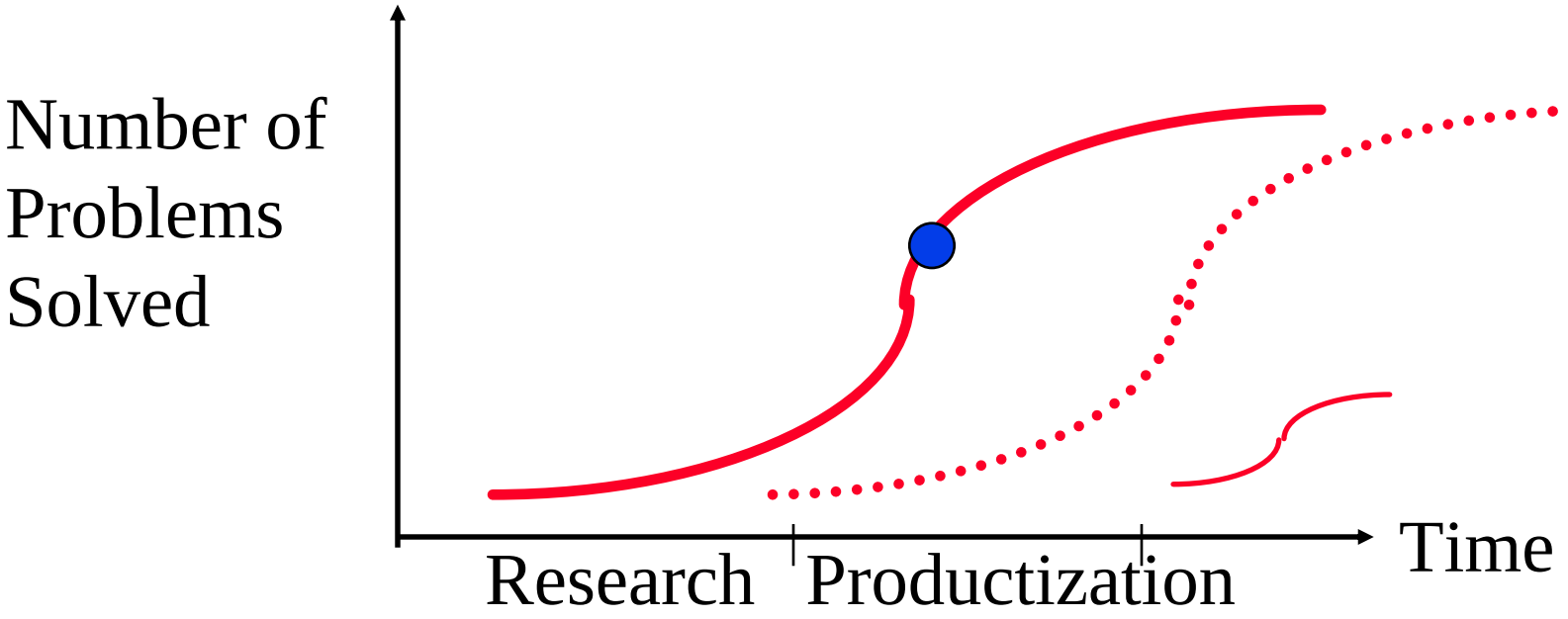
Life Cycles of Technologies



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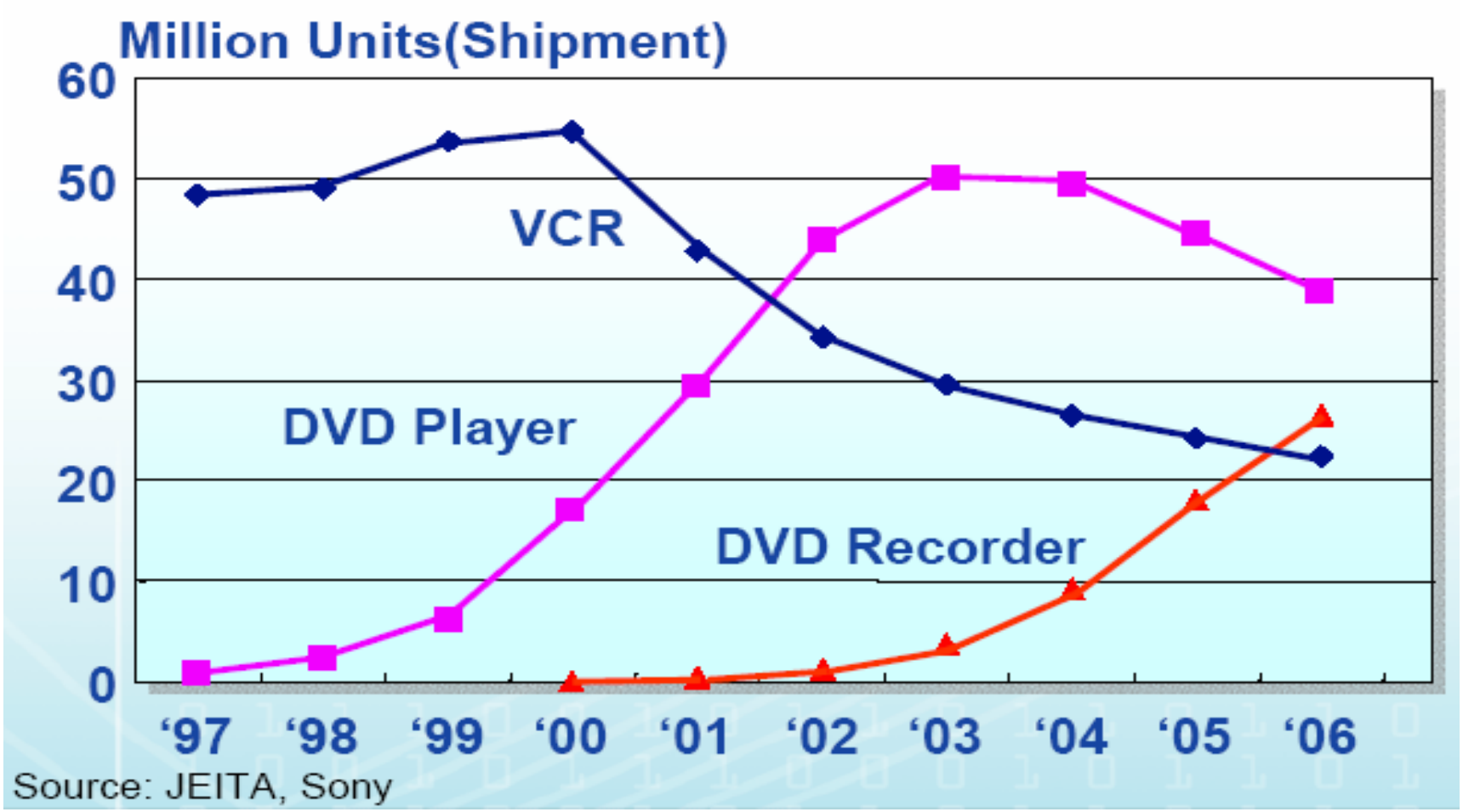
VCR vs DVD



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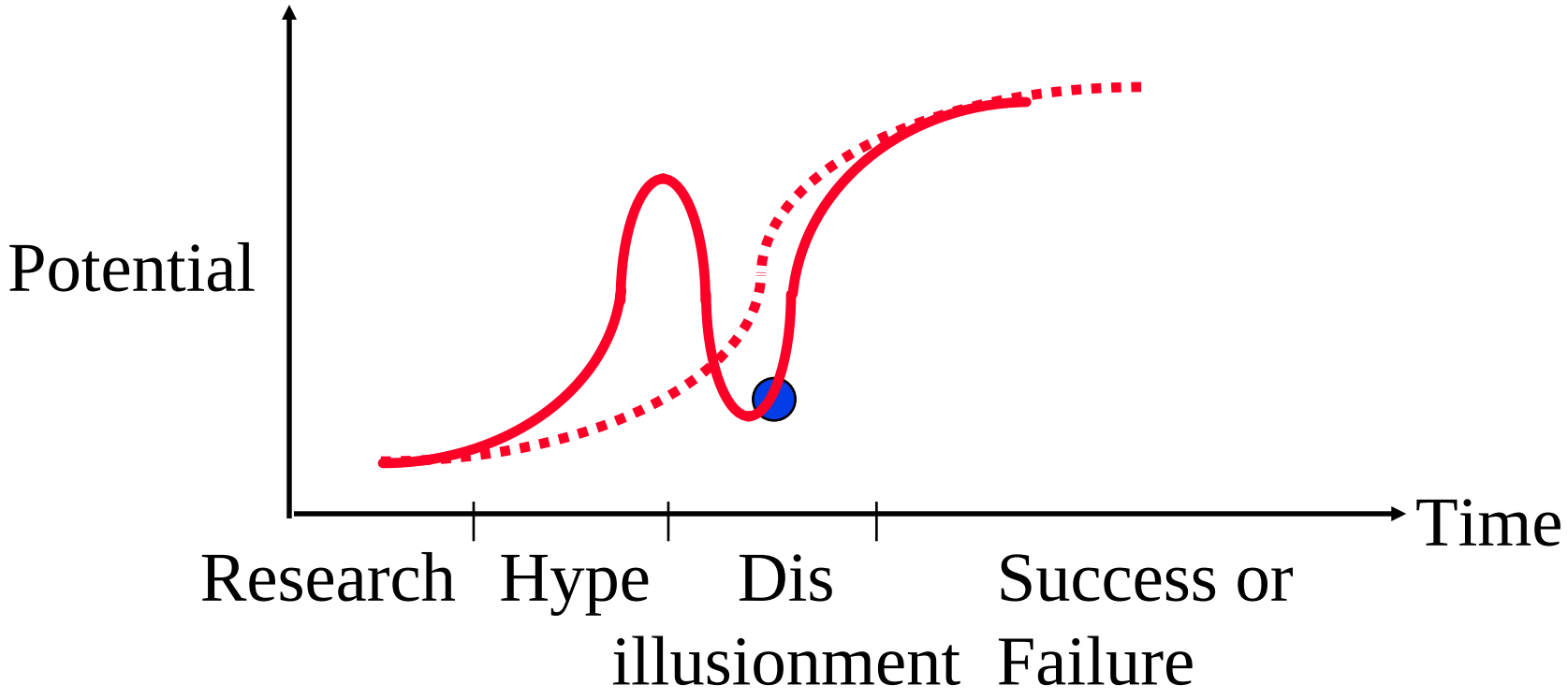
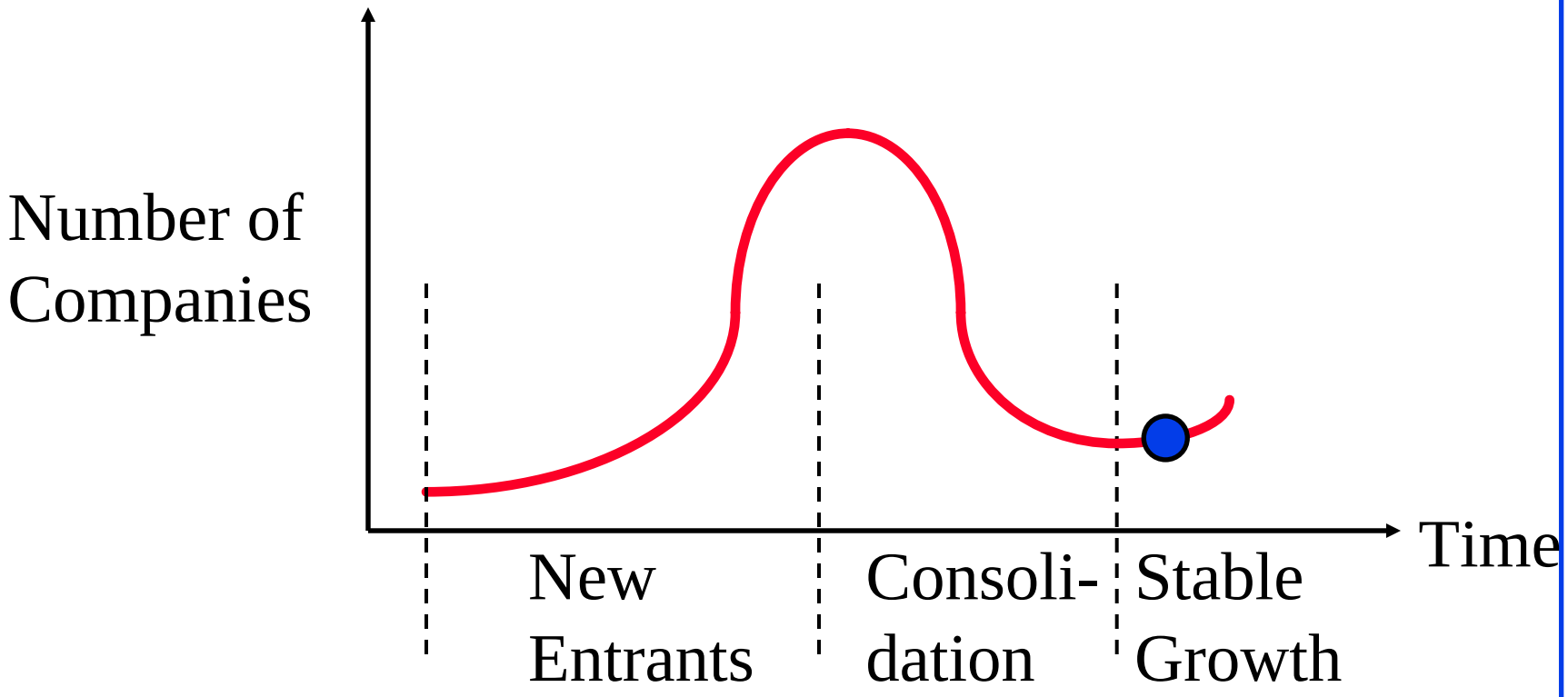
Hype Cycles of Technologies



Industry Growth



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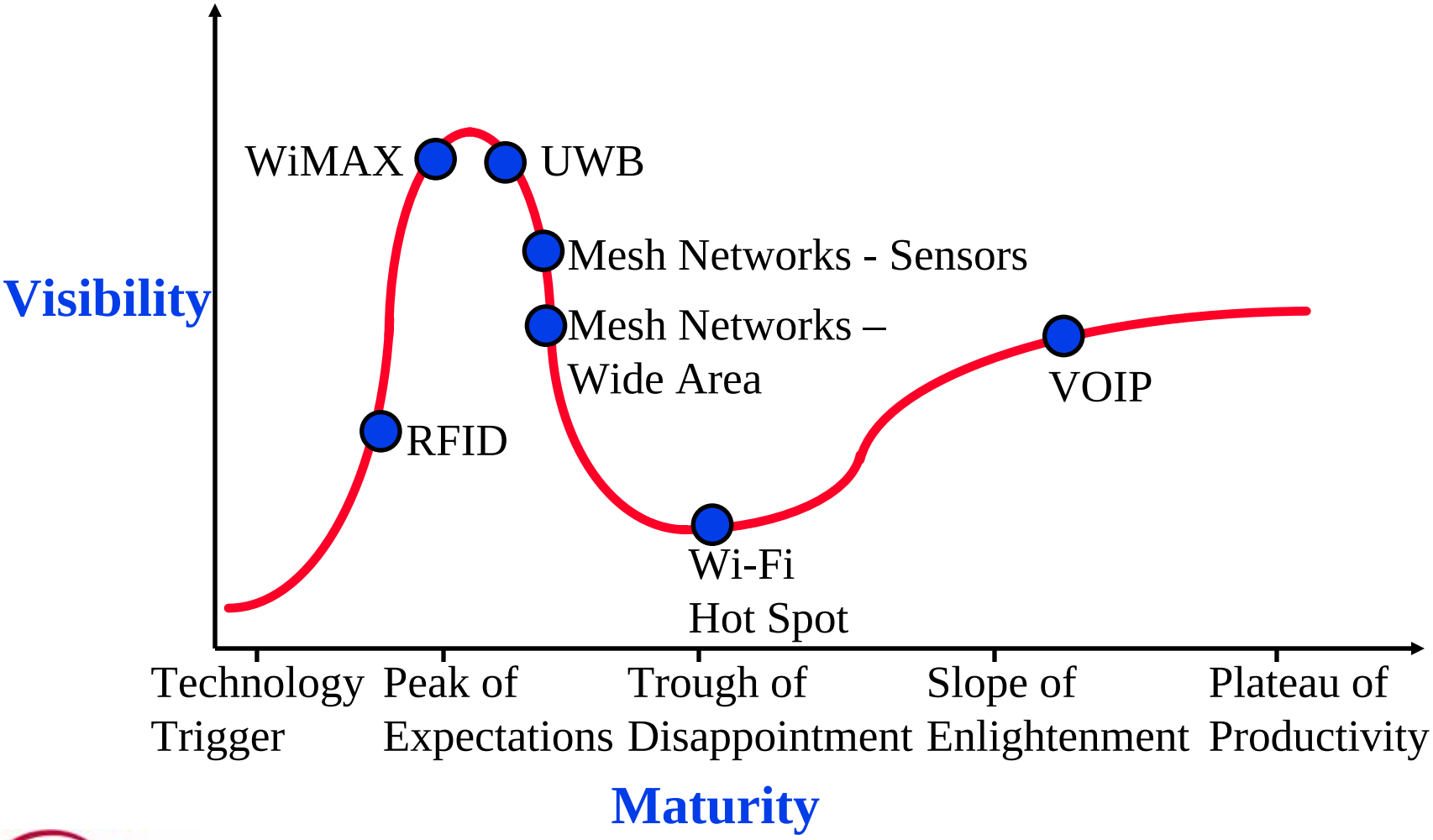
Hype Cycle 2004



Based on Gartner Research (July 2004)

Top 10 Developments of 2004

1. Large investments in Security: Message Aware Networking
   ⇒ 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 ⇒ 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 ⇒ 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) ⇒ High-Speed Networking
    Grid Storage. Desktop search.

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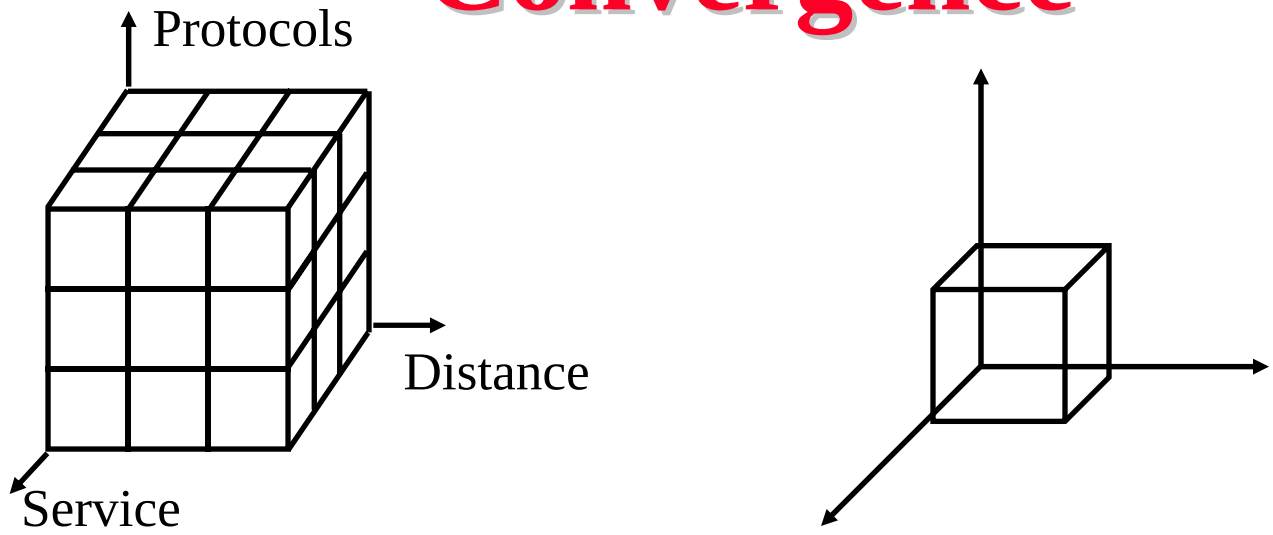
Convergence



- 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

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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

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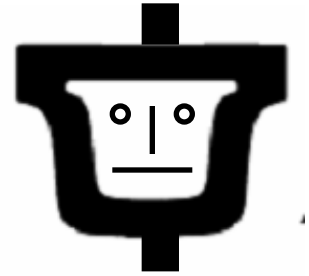
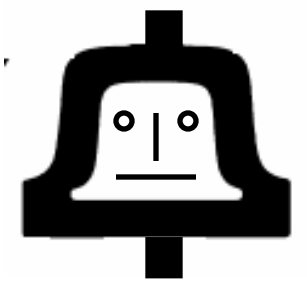
Ethernet: 1G vs 10G Designs





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

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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 ⇒ Evolution
- High Performance
- Killer Applications
- Timely completion
- Manageability
- Interoperability
- Coexistence with legacy networks
  Existing infrastructure is more important than new technology (IPv6, IP multicast)

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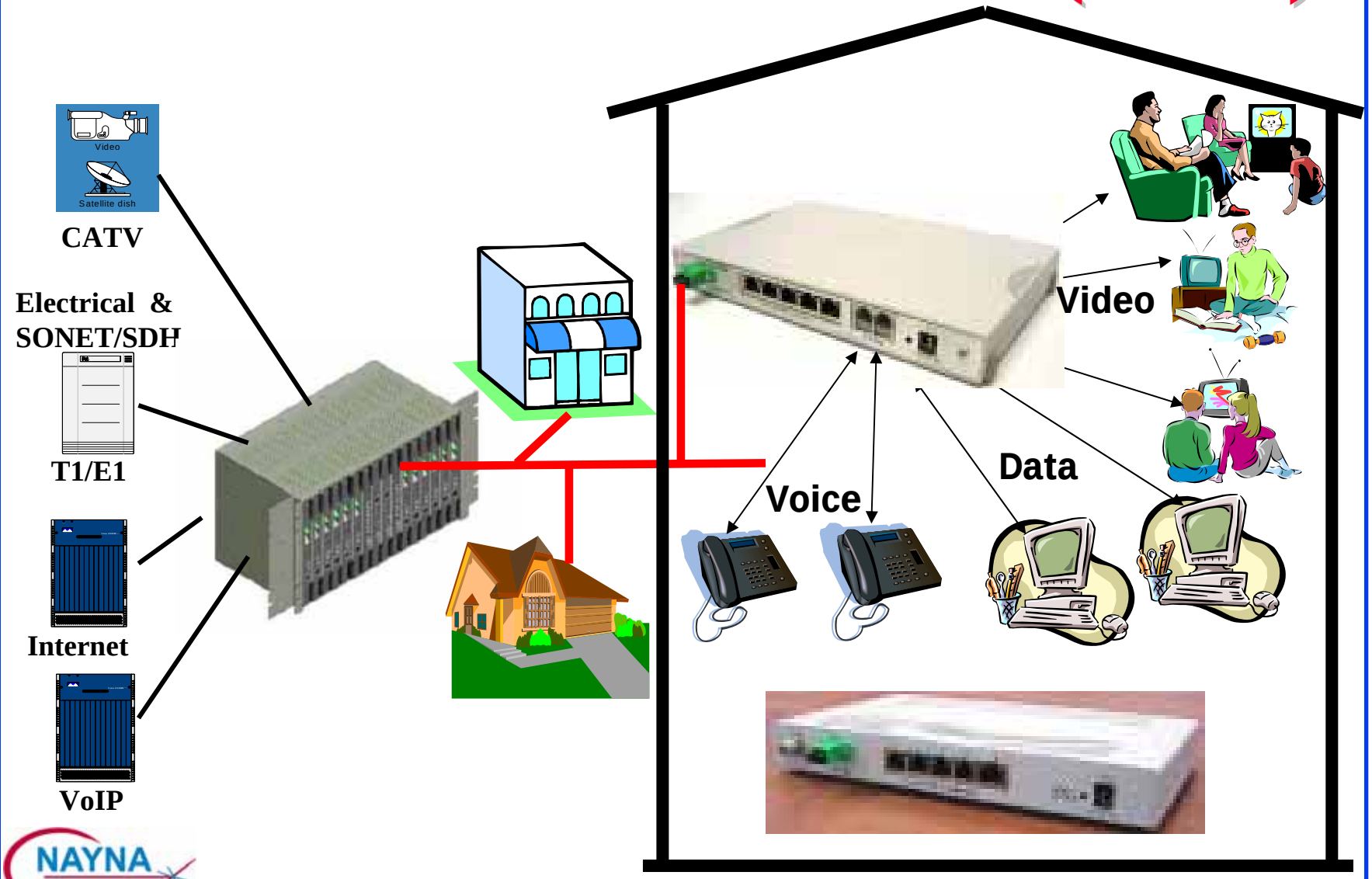
Access Networks

- 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

Ethernet to the First Mile (EFM)



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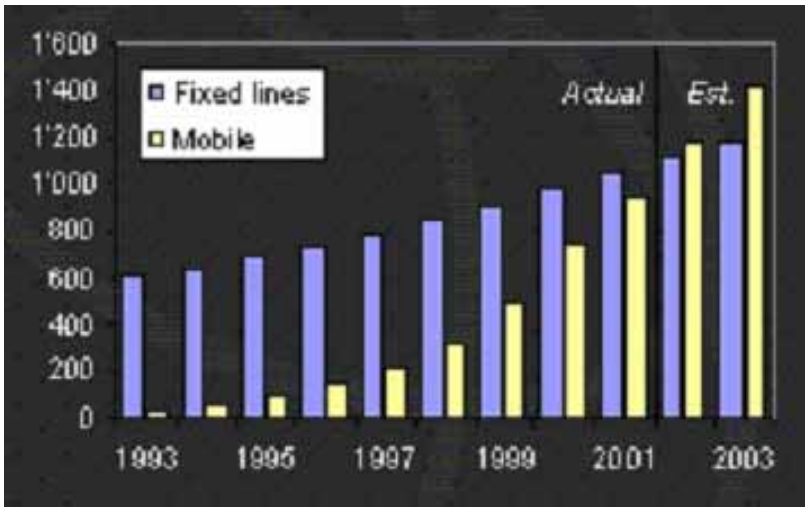
Mobility

- 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)



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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,

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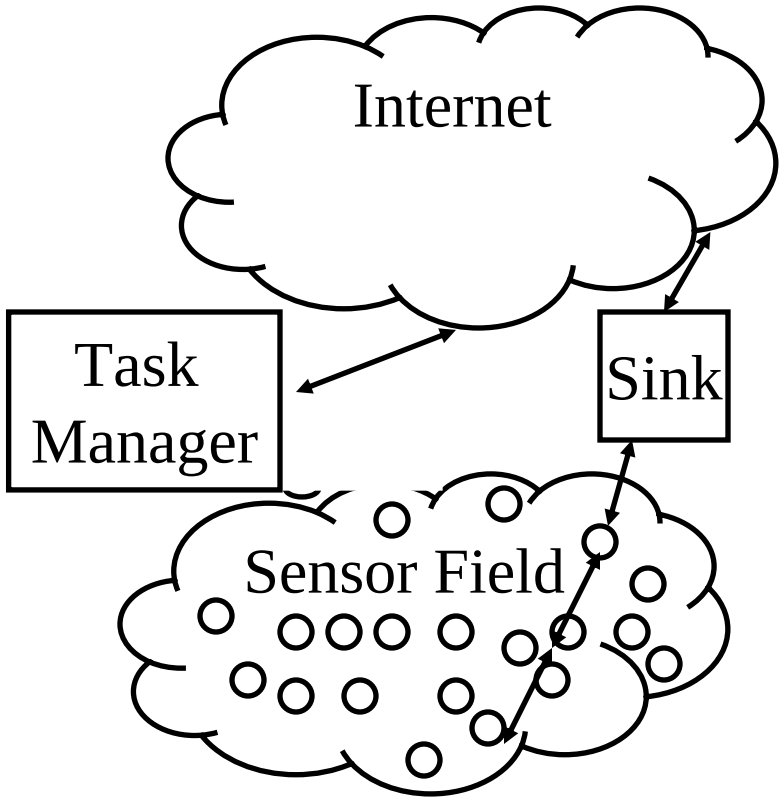
Wireless Issues

- Security (IEEE 802.11i)
- Higher Data Rates:
  - Ultra-wide band (vs Bluetooth)
  - Wireless USB
  - Multiple In Multiple Out (MIMO) antennas: IEEE 802.11n
- Longer distance (WiMAX, >1Mbps to 50 km)
- Seamless Networking ⇒ Handoff (IEEE 802.21)
- Mobility (IEEE 802.20)
- Multimedia over Wireless:
  - Media center extenders
  - VOIP/Video over cell phones
- 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



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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

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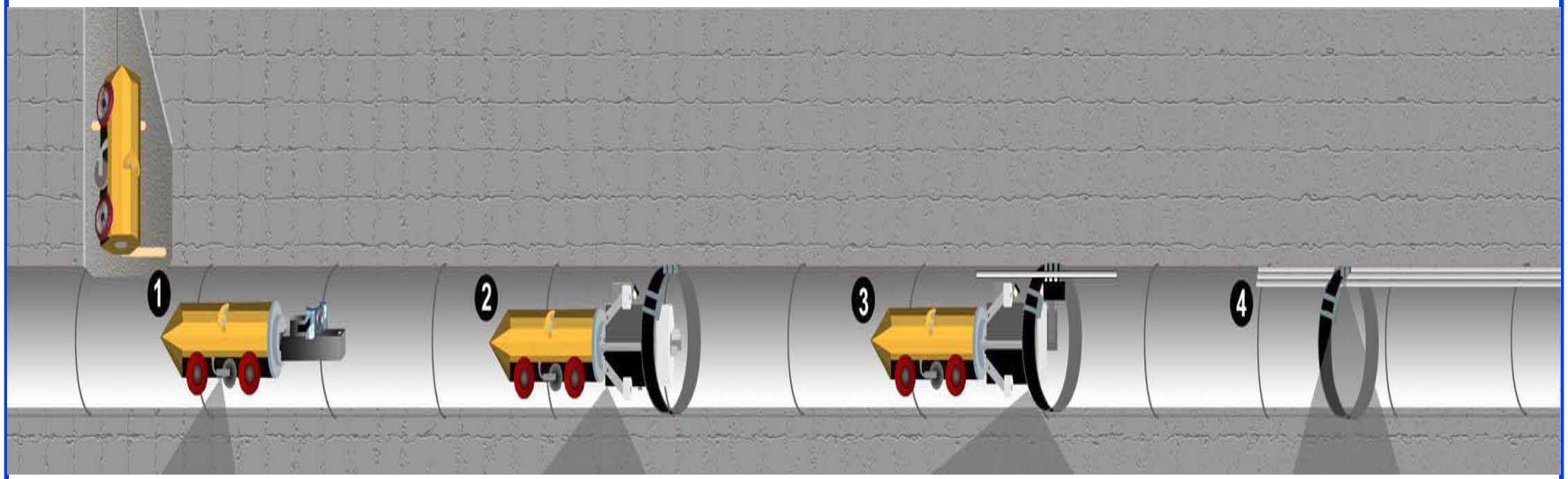
FAST Installation



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

Fast Restoration: Broken sewer pipes replaced with minimal disruption

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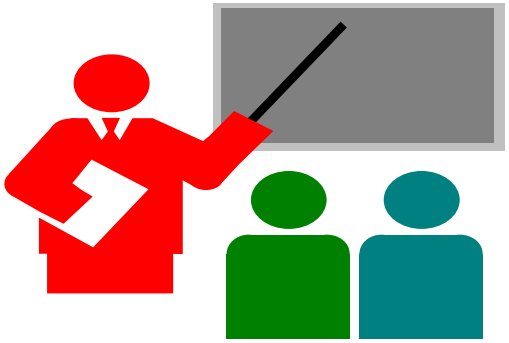

Summary

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. Low cost is the key to success of a technology
4. Wireless is where the action is. MIMO is in. CSMA/CD is out.
5. Key issues in Wireless are: Security, Mobility, and high-speed

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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