Computer Networking: Recent Developments, Trends, and Issues

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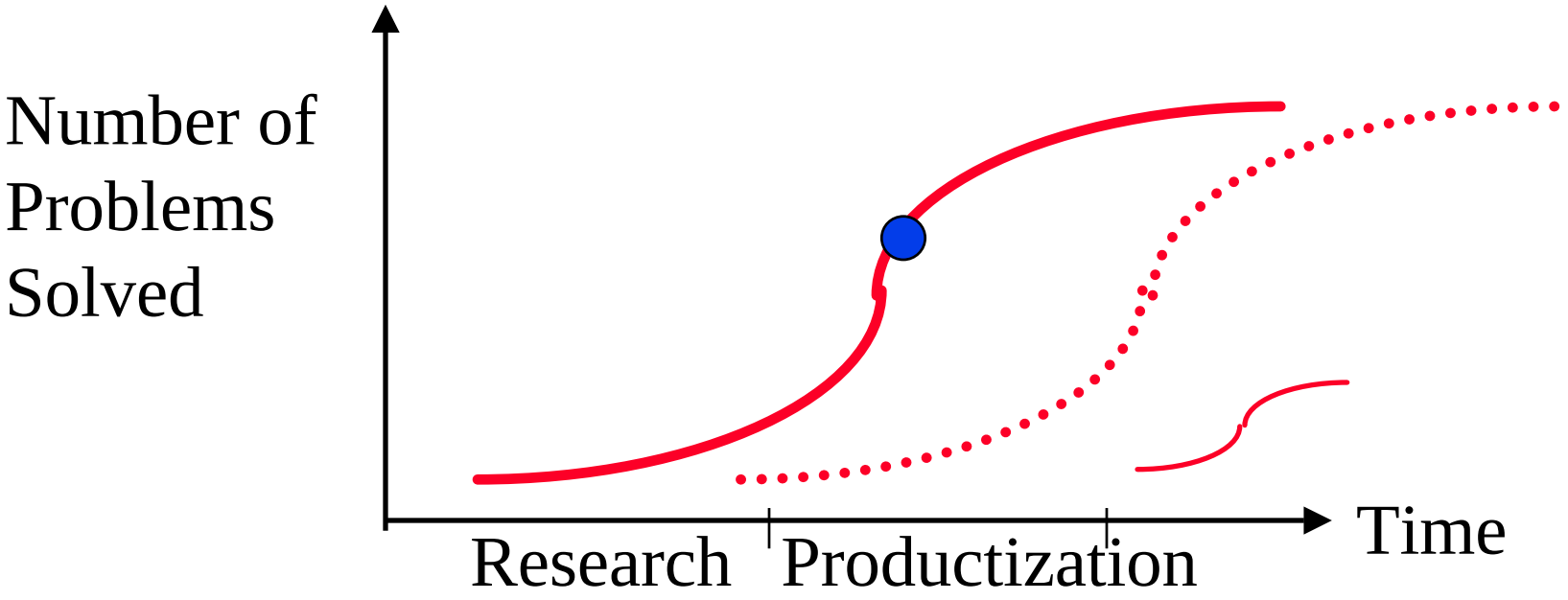
This on-line version does not include cartoons used during the presentation.

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

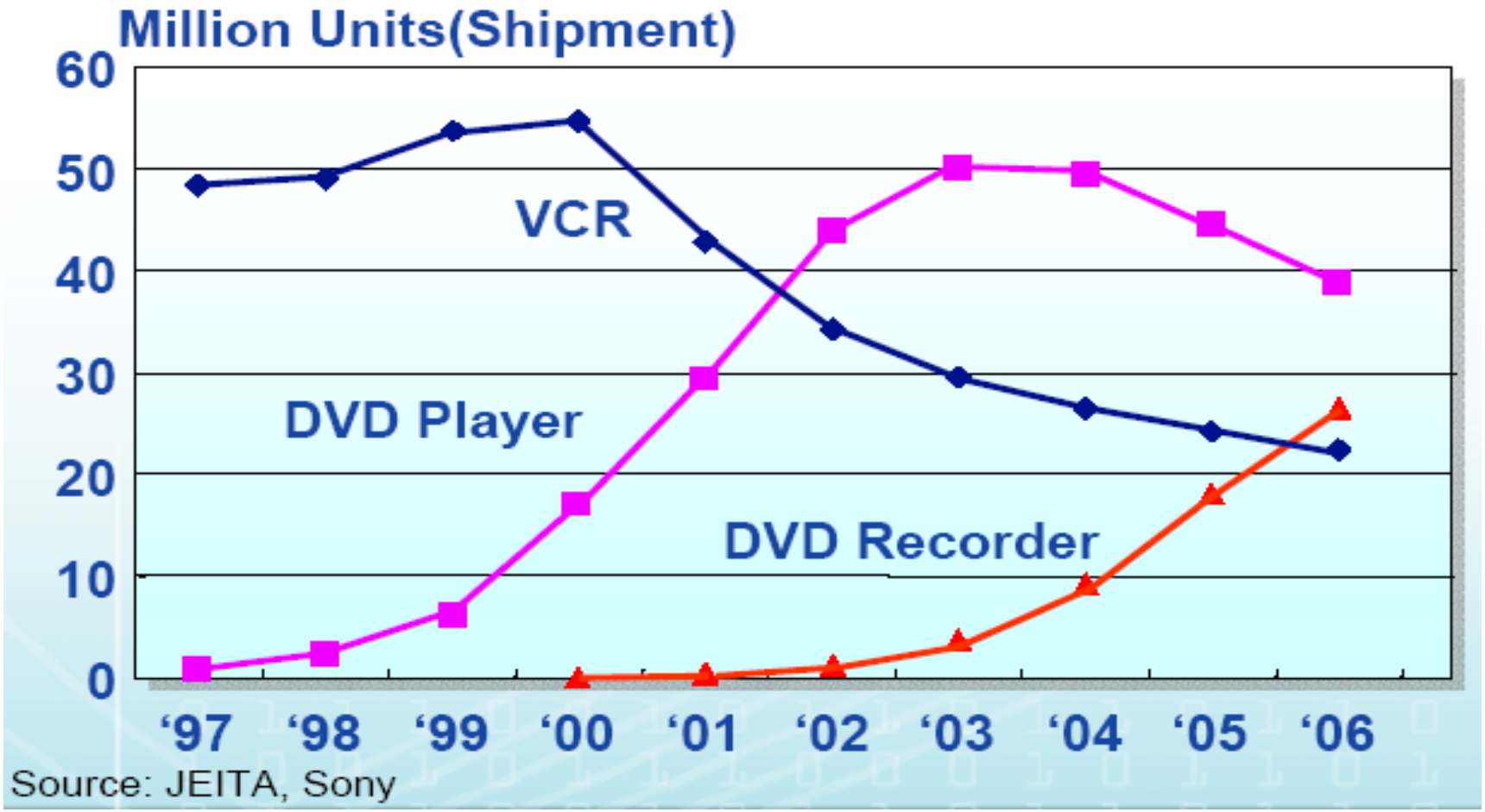
Trend: Back to ILECs

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
   $\Rightarrow$ Equipment that support voice circuits but allow packet based (hybrids) are more important than those that allow only packet based

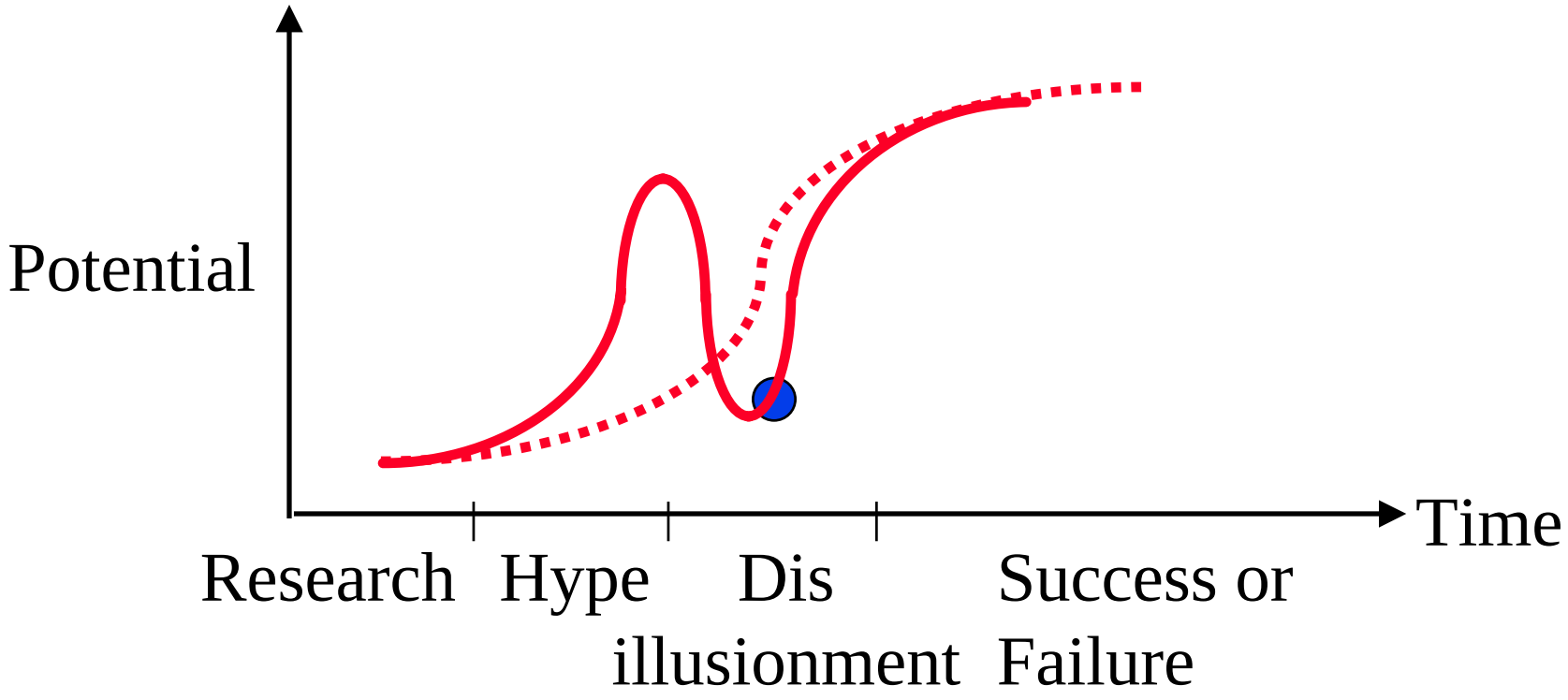
Life Cycles of Technologies



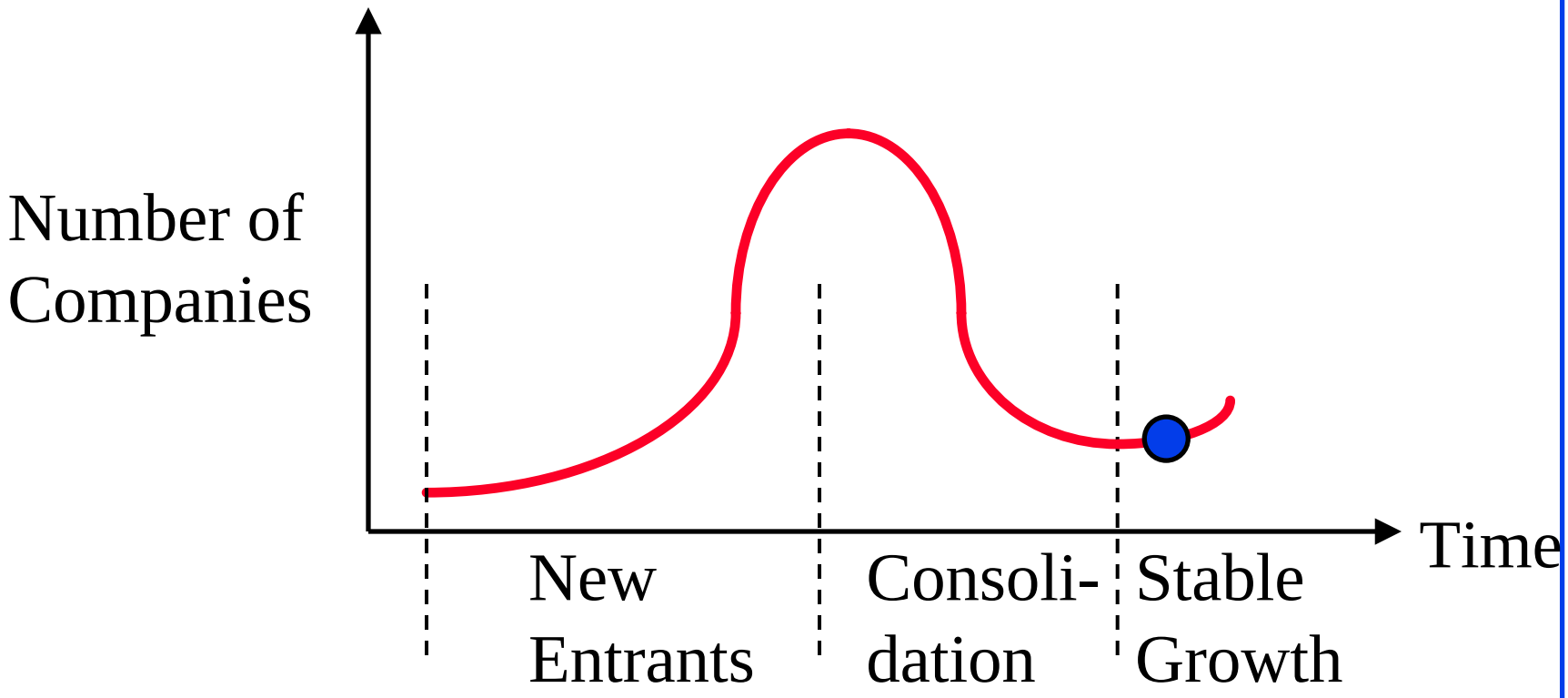
VCR vs DVD



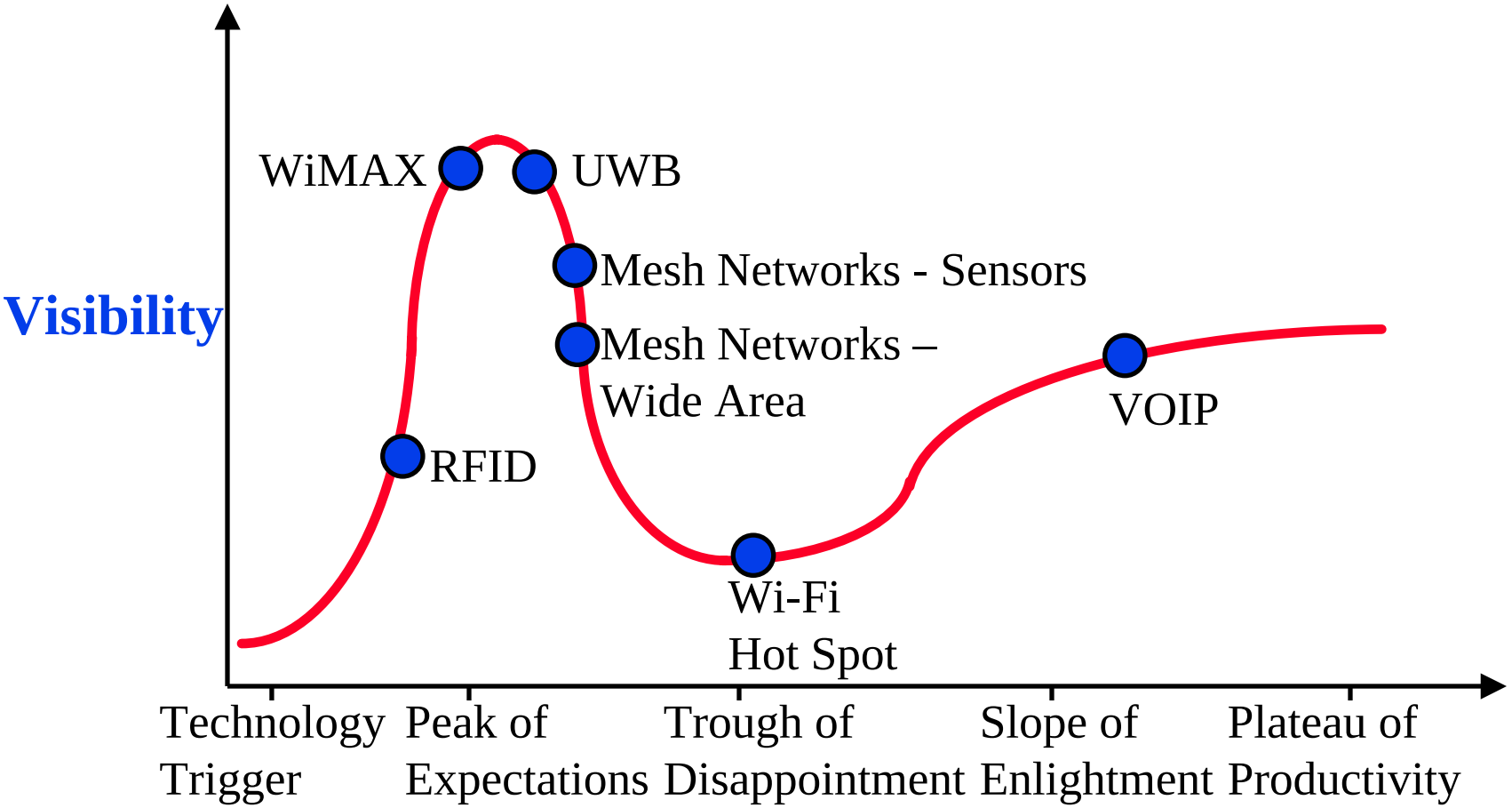
Hype Cycles of Technologies



Industry Growth



Hype Cycle 2004



Based on Gartner Research (July 2004)

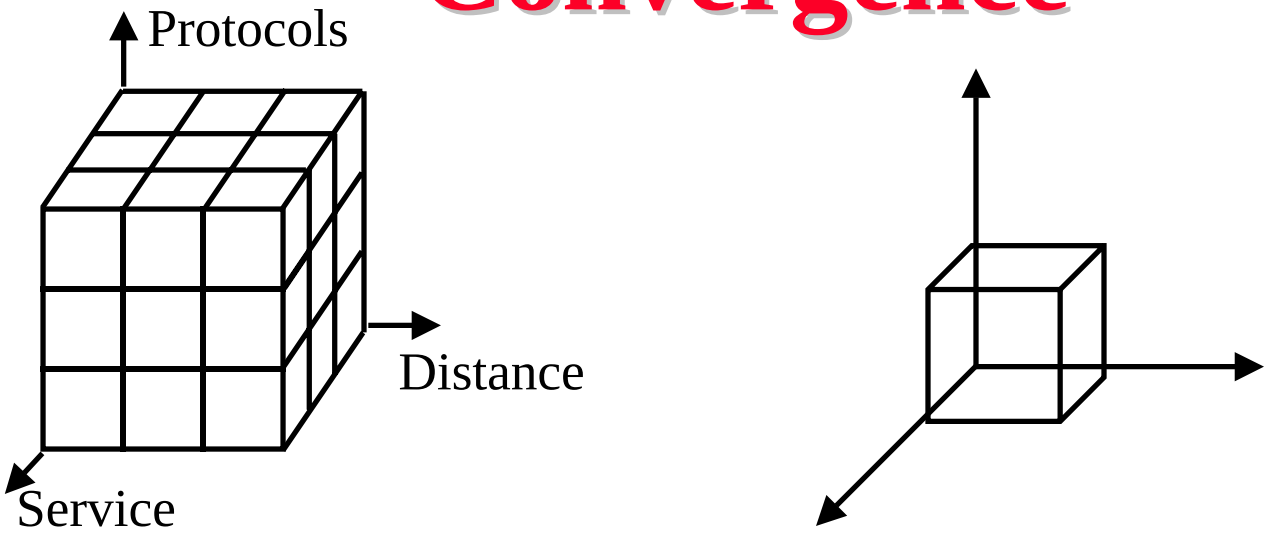
Technology Cycles

- Peter Drucker: A 10 fold increase in anything represents a discontinuity for humans
- Industrial Age: Started around 1750
  - Industrial power doubled every 18 years
  - 4 Discontinuities in 250 years $\Rightarrow$ 1 every 62 years
- Semiconductor Age: Planar process 1960
  - Density doubles every 18th month
  - 7 Discontinuities in 25 years $\Rightarrow$ 1 every 5 years
  - Created $1 Trillion in US market capitalization
- Networking Age: 1995 onwards. Traffic doubles every year.
  - 10BASE-T(1988), 10GBASE-CX4 (2004) = 1000 in 16 Yrs
  - 1 Discontinuity every 5 years

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



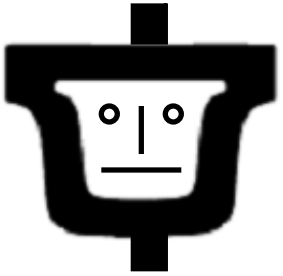
- Distance: LAN vs MAN
- Services: Data, Voice, Video
- Phy: Circuit switched vs Packet switched
- L2 Protocols: Ethernet and SONET
- L3 Protocols: IP
- HTTP: Hyper-Application Access protocol

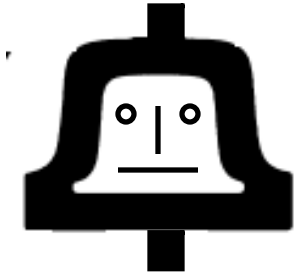
Core Networks

- 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	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

SONET/SDH vs Ethernet: Remedies

Feature	SONET	Ethernet	Remedy
Payload Rates	51M, 155M, 622M, 2.4G, 9.5G	10M, 100M, 1G, 10G	10GE at 9.5G
Payload Rate Granularity	Fixed	√Any	Virtual Concatenation
Bursty Payload	No	√Yes	Link Capacity Adjustment Scheme
Payload Count	One	√Multiple	Packet GFP
Protection	√Ring	Mesh	Resilient Packet Ring (RPR)
OAM&P	√Yes	No	In RPR
Synchronous Traffic	√Yes	No	MPLS + RPR
Restoration	√50 ms	Minutes	Rapid Spanning Tree
Cost	High	√Low	Converging
Used in	Telecom	Enterprise	

Enterprise vs Carrier Ethernet

Enterprise

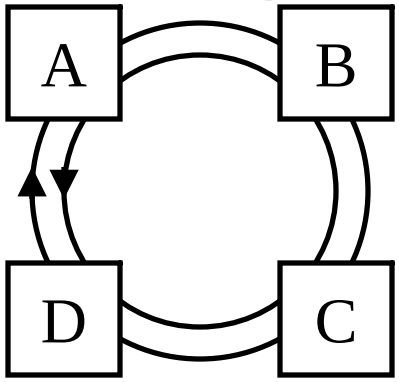
- Distance: up to 2km
- Scale:
  - Few K MAC addresses
  - 4096 VLANs
- Protection: Spanning tree
- Path determined by spanning tree
- Simple service
- Priority ⇒ Aggregate QoS
- No performance/Error monitoring (OAM)

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. Rate Control.
- Need per-flow QoS
- 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)

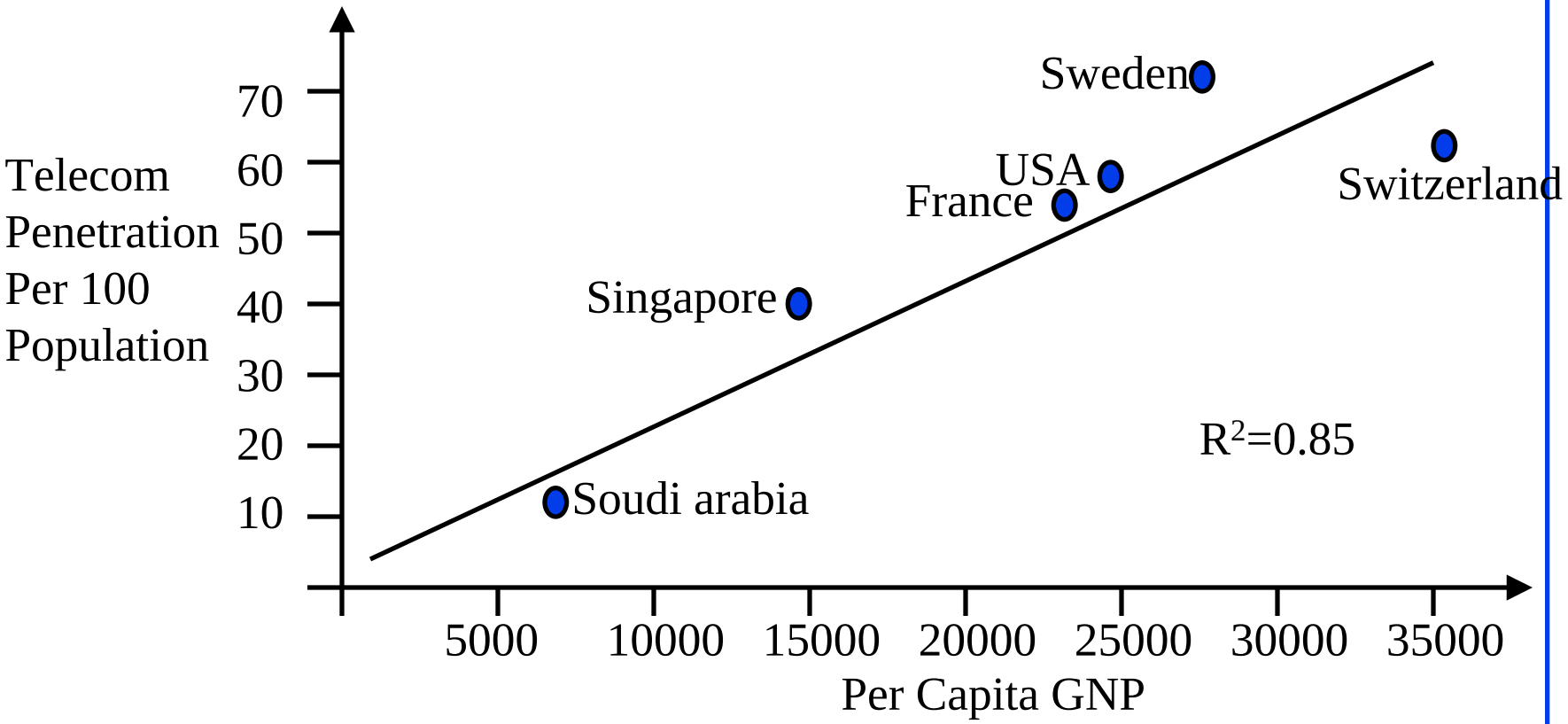
Networking: Failures vs Successes

- 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

Telecom and Economic Development



- Fundamental correlation between GDP growth and teledensity

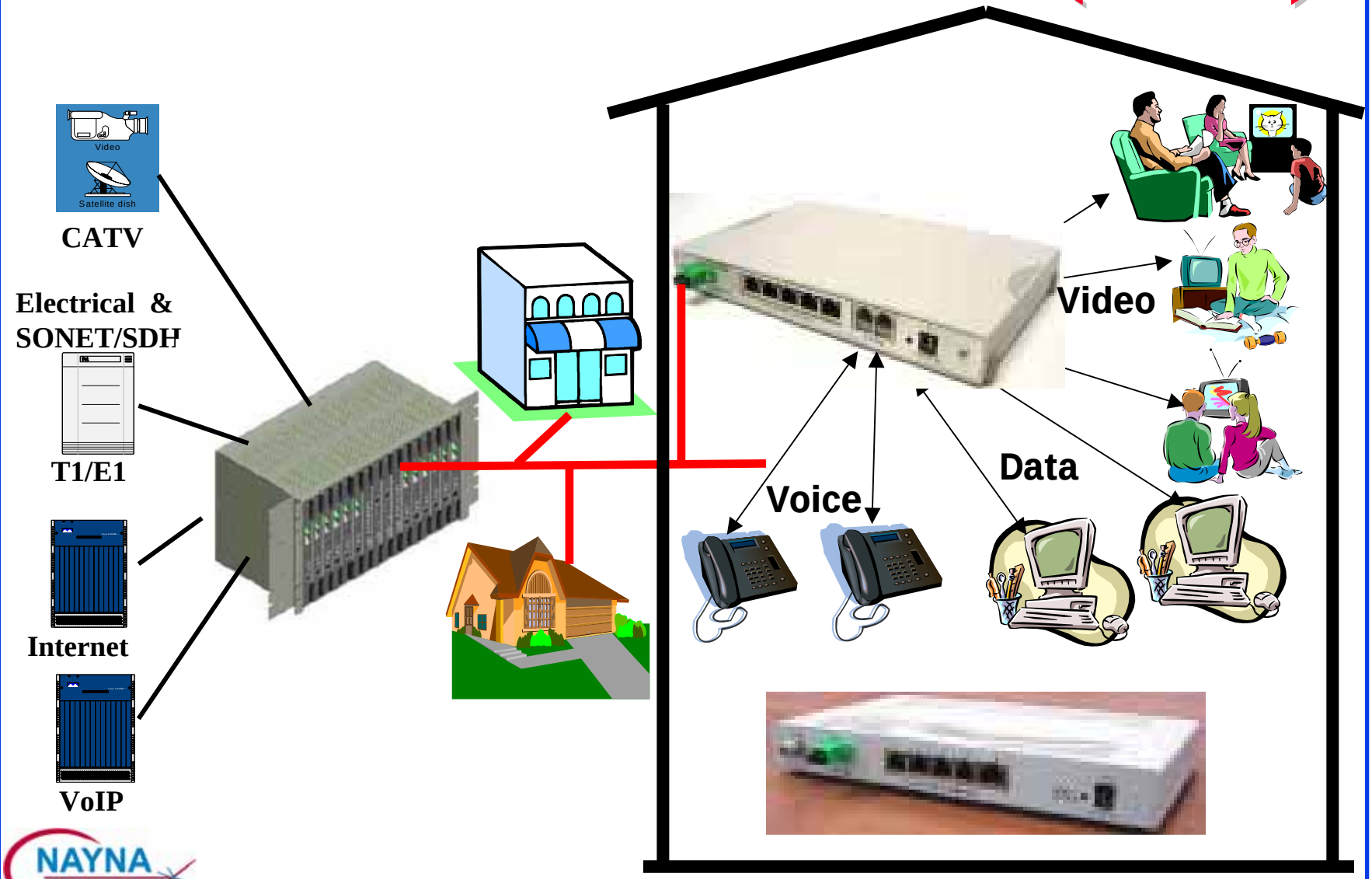
Source: ITU

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

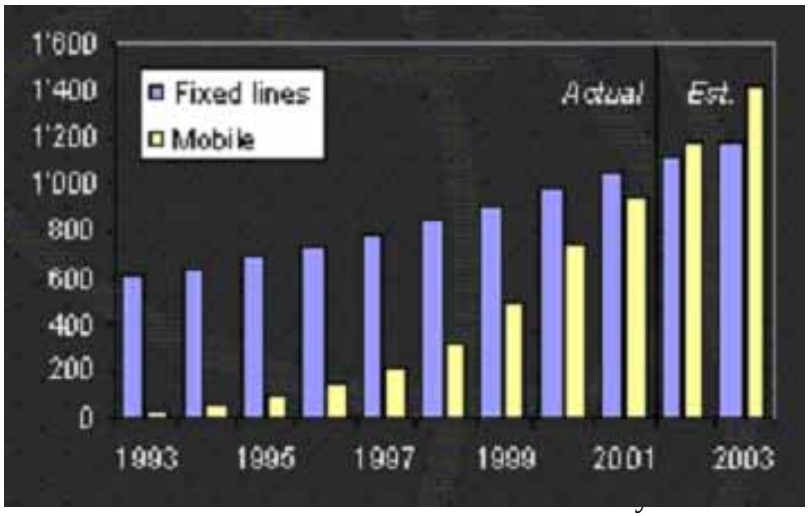
Rank	Country	DSL per 100 Phones	Rank	Country	DSL per 100 Phones
1	South Korea	28.3	6	Israel	14.5
2	Taiwan	19.8	7	Denmark	14.2
3	Belgium	16.7	8	Finland	13.6
4	Hong Kong	16.1	9	Singapore	13.4
5	Japan	15.7	10	France	12.1
			32	USA	5.6

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)



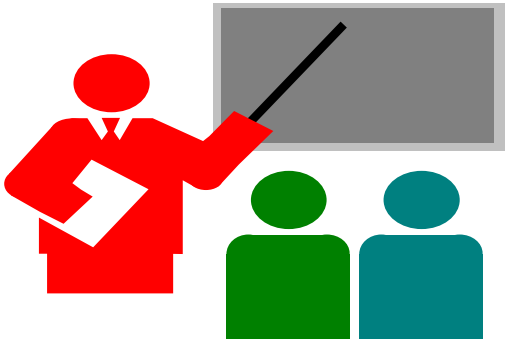
NAYNA Networks

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 antennae)
- Longer distance (WiMAX, >1Mbps to 50 km)
- Seamless Networking ⇒ Handoff (IEEE 802.21)
- Mobility (IEEE 802.20)
- Automated RF management (Cell sites)
- Large scale networks (RFID, Sensors)



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