Broadband Internet

Broadnets 2004

Vint Cerf

MCI

October 28, 2004

Creation of the Internet

35th Anniversary of ARPANET

- Sept 2, 1969, the first node of the ARPANET was installed at UCLA
- The success of this first wide-area packet switching network inspired the creation of the ground mobile Packet Radio Net and the Packet Satellite Net
- These became the core of the Internet

30th Anniversary of TCP/IP

- May 1974: “A Protocol for Packet Network Intercommunication,” Vint Cerf and Bob Kahn, IEEE Transactions on Communications
- A copy of this was auctioned for $3,000 in 2002
- Another copy is in a NY antiquarian bookstore for $7,500 in 2004

IEEE TRANSACTIONS ON

COMMUNICATIONS

MAY 1974 VOLUME COM-22 NUMBER 5

A PUBLICATION OF THE IEEE COMMUNICATIONS SOCIETY

Internet - Global Statistics

22.5 Million Hosts
(Bellcore June 1997)

50 Million Users
(NUA Jul 1997)

250 Million Hosts
(ISC Apr 2004)

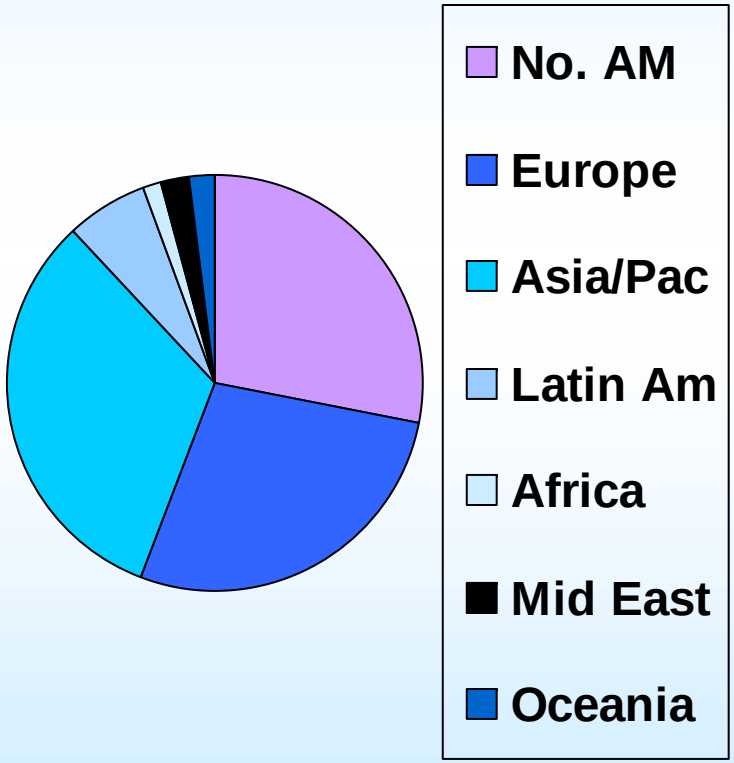
797.9 Million Users
(InternetWorldStats.com August 2004)
[Other estimates range from 850M-950M]

(approx. 2.3 Billion Telephone Terminations, 600 Million PCs [ITU] and 1.34B mobile phones; Washington Internet Daily, 10/6/04)

Internet Penetration Aug. 2004

- Asia - 255.6 M
- No. Amer. -223.8 M
- Europe - 222.2 M
- Latin Am - 51.2 M
- Africa - 12.3 M
- Mid-east - 16.8 M
- Oceania- 16.0 M

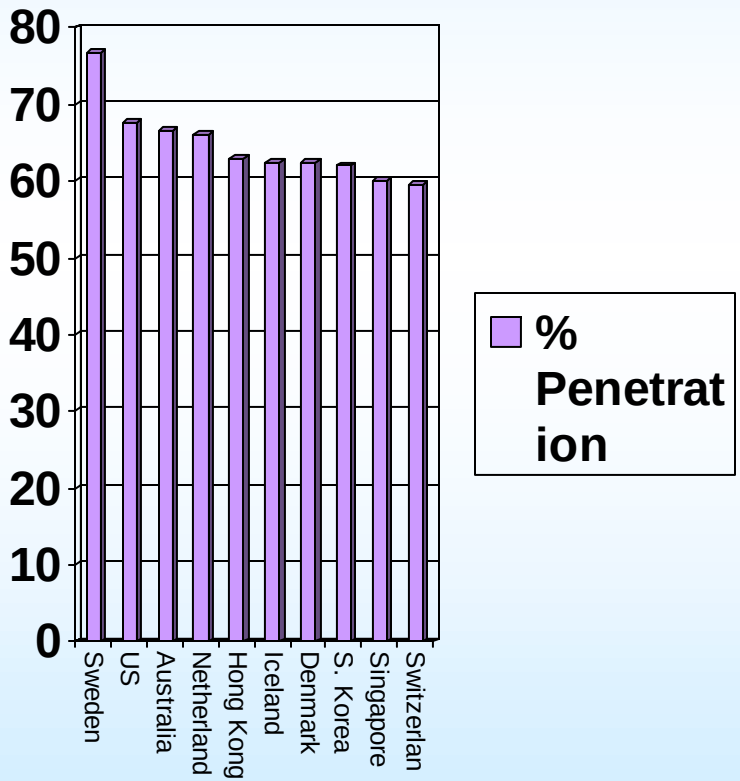
- Total - 797.9 M



(Source www.internetstats.com)

% Internet Use (May 2004)

- Sweden (76.8%)
- United States (67.6%)
- Australia (66.6%)
- Netherlands (66.0%)
- Hong Kong (63.0%)
- Iceland (62.5%)
- Denmark (62.5%)
- S. Korea (62.0%)
- Singapore (60.0%)
- Switzerland (59.6%)

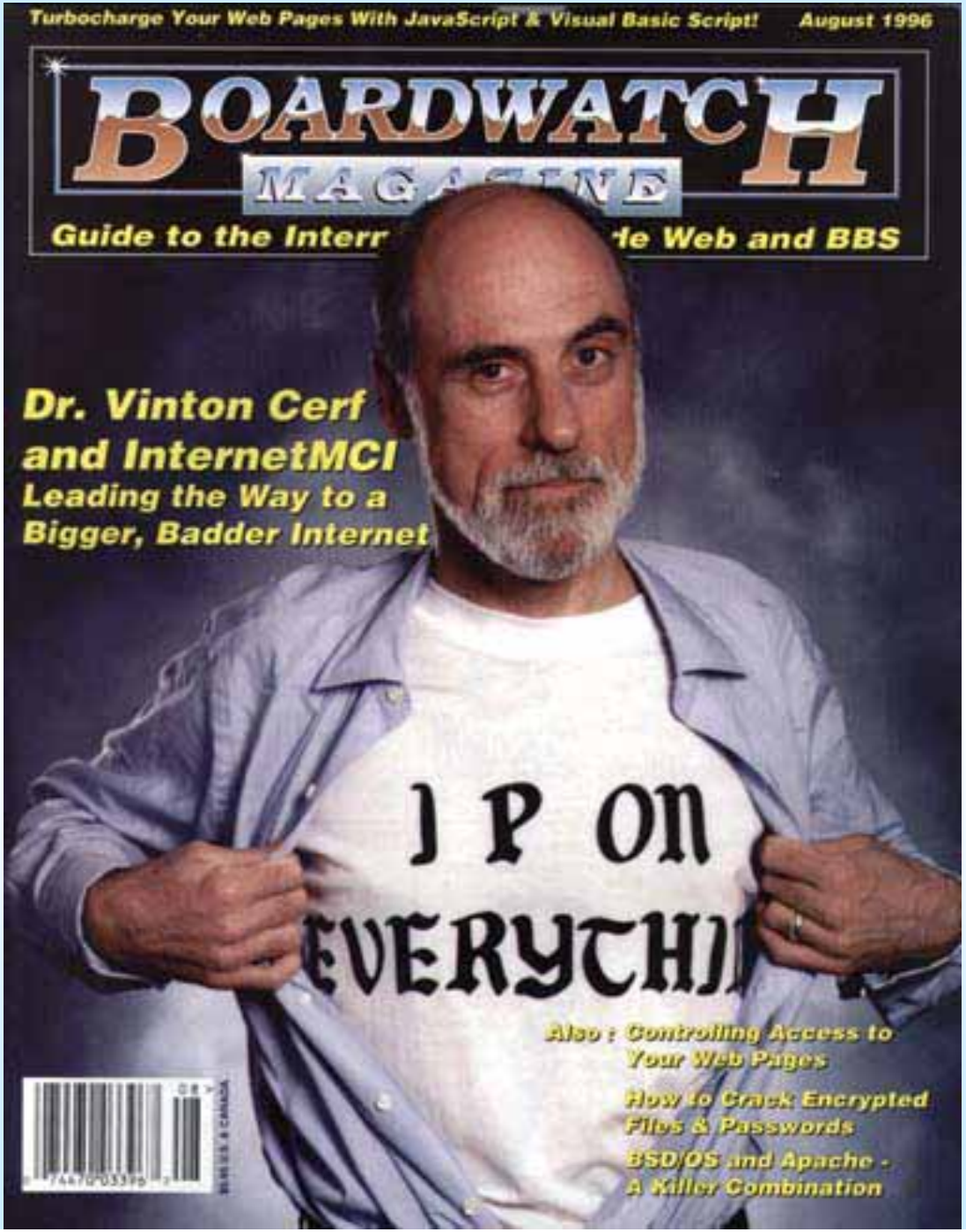


Total 66.7% (274.3 M)

ROW 7.8% (471.1 M)

The Power of IP

- Layering of Protocols
- IP decouples application from transmission/transport
  - IP does not care what transport is used (satellite, fiber, twisted pair, radio, ATM…)
  - IP does not care what application it is carrying (video, audio, web, email…)
- Embedding of all modalities under program control via IP
- Profound impact on regulatory models


Turbocharge Your Web Pages With JavaScript & Visual Basic Script!
August 1996
BOARDWATCH
MAGAZINE
Guide to the Interr
le Web and BBS
Dr. Vinton Cerf
and InternetMCI
Leading the Way to a
Bigger, Badder Internet
Also : Controlling Access to
Your Web Pages
How to Crack Encrypted
Files & Passwords
BSD/OS and Apache -
A Killer Combination

The Freedom of the Internet

- End/End principle drives opportunity and experimentation – no permissions needed
- Layering future-proofs the IP layer for all transport media
- Convergence of traditional services
- The WWW open to all inputs and information sharing (e.g. note effect on scientific research)

Broadband Observations

- Core Data Rates
  - Ultra Long-Haul (1500+ km) w/o repeaters
  - 40 Gb/s per lambda, 160 lambdas/fiber
  - 6.4 Tb/s per fiber
- Edge “broadband”
  - Asymmetry (DSL, Cable Modem, Satellite)
  - FTTx (Curb, Home, Building) - symmetric
  - 1-10 Gb/s near-mid term

Wireless Edge Capacity

- 802.11x (10-100 Mb/s)
- 802.15, 802.16 (10-100 Mb/s)
- EV-D0 (500 – 1000 Kb/s?)
- UWB (up to 1 Gb/s?)
- Phased Arrays (Frequency Reuse)
- Optical (10 Mb/s-10 Gb/s)?

Global Capacity Requirements

- 10^9 end devices @ 10^8 bps = 10^{17} bps
- Edge fanout = 100
- Edge router capacity:
  - $10^2 X 10^8 = 10^{10}$ bps = 10 Gb/s
- Assume each net has a factor of 100 aggregation above edge
- 10^5 networks carrying 10^{12} bps each

Pushing the limits

- 10^{17} bps aggregate demand
- 6.4 X 10^{12} bps per fiber
- 10/6.4 X 10^{16} /10^{12} fibers ~ O(2000) backbone interconnect fibers

Application Computations

- Compressed DTV: 1.5 GB/1 hour film
- MovieBeam (Disney): 10 movies/week
- Repeat TX 5 times
- 50X1.5 GB = 75 GB
- 75 GB/(7X24X3600 sec)= O(1 Mb/s)
- But note: @ 1Gb/s = 12 sec!!

More Applications

- Chip Design/Performance Data
  - 500 GB (4 Tb)
  - @1 Gb/s = 4000 sec
  - @10 Gb/s = 400 sec
- VOIP/Video over IP (VIP?)
  - 2.3 B devices = 1.2 B “conversations”
  - VOIP: 1.2 B X 10 Kb/s = only 12 Tb/s
  - VIP: 1.2 B X 1 Mb/s = 1200 Tb/s ($1.2X10^{15}$)
    - Only 1% of 10^{17} bps net capacity

Sensor Networks

- Environmental sensors (HVAC, pollutants, meteorological, security, terroir…)
- Equipment instrumentation (automobiles, appliances, buildings, light bulbs/sockets, power plants…)
- Vital sign monitoring (pulse, EKG, EEG, oxygenation, blood factors, …)
- On the order of billions of sensors
- 100 devices/person X 6 B X 1000 bps
  - = 6 X 10^{14} bps

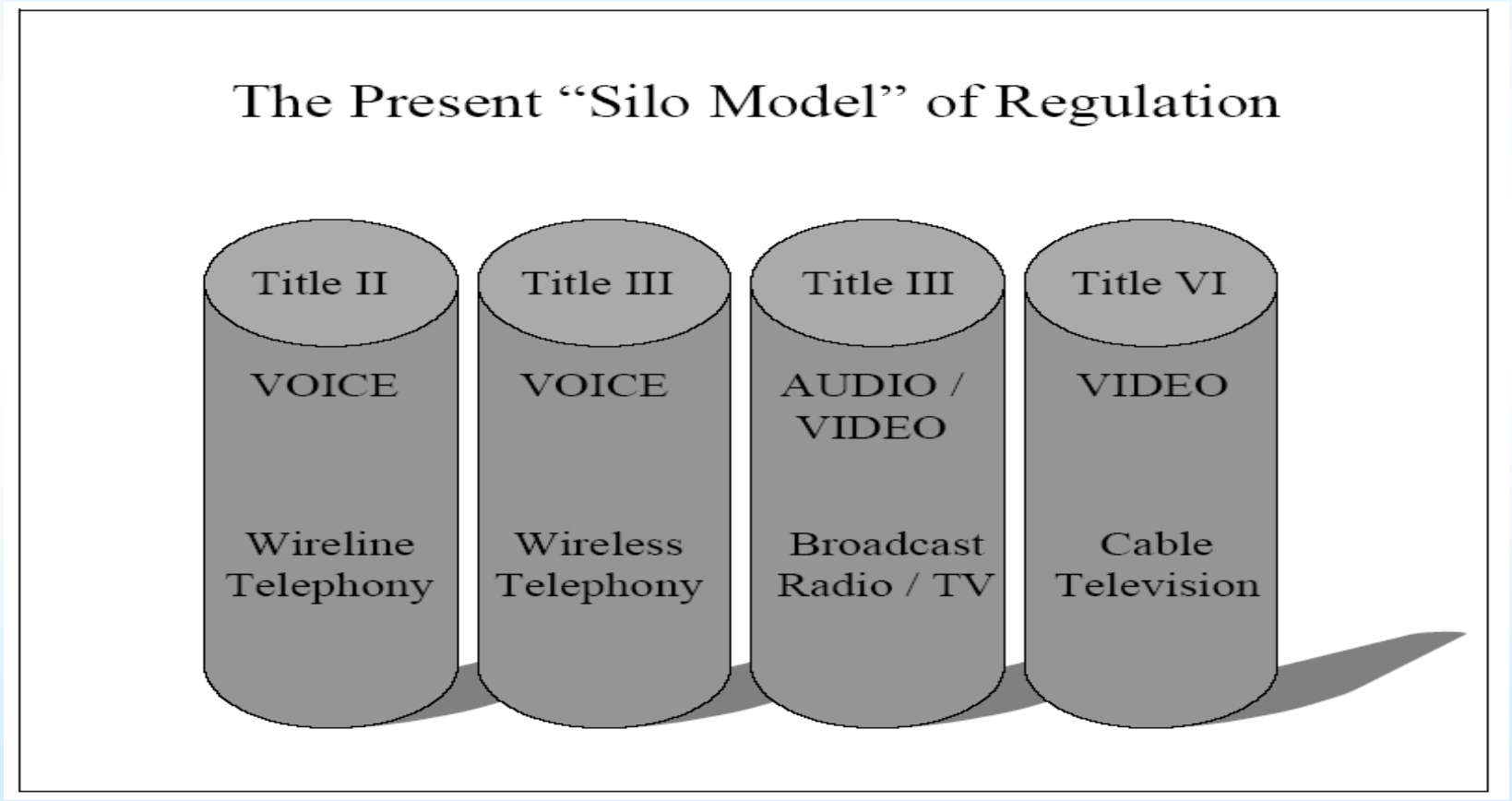
Transaction Processing

- 6 B X 2 hrs video/day downloaded
  - 6 B X 9 GB/day = 6 X 10^9 X 72 X 10^9 bits/day = 432 X 10^{18} bits
  - about 1.2 hours at 10^{17} bps
- 6 B X 200 email/day X 30KB/msg
  - O (3X10^{17} bits/day)

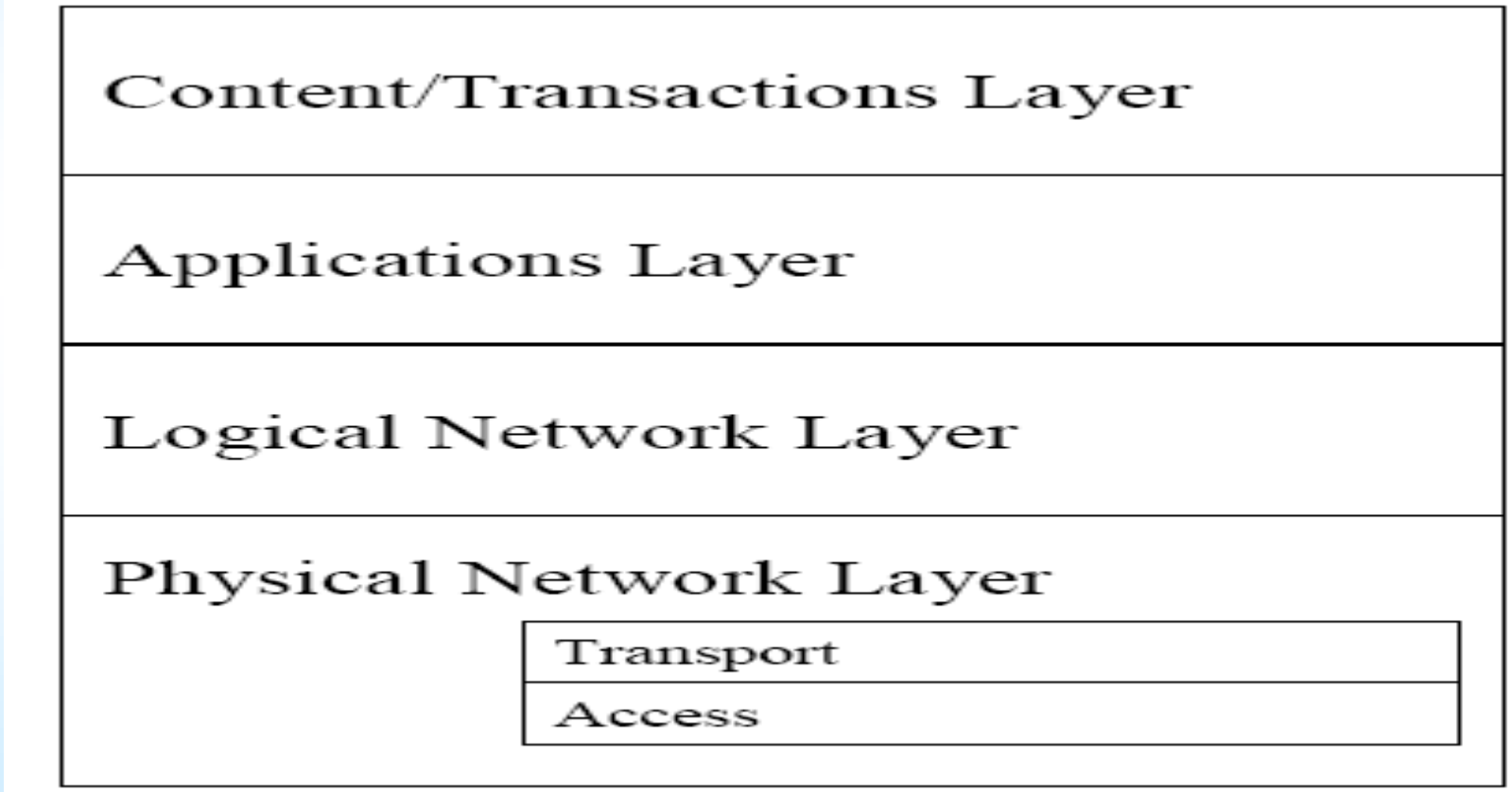
Some Barriers to Broadband

- Router Architecture
- Policy
- Wireless Interference

Vertical Regulation



MCI Proposed Model



Regulatory Layering

- Confine regulation to appropriate layer
- Minimize layer-crossing regulation
- Fit regulation to appropriate layer to avoid over-regulation or under-inclusion
- Defend against abuse of market power control of one layer to control higher ones
- Regulate only when market forces at a given layer fail to provide fair competition

Applicability of Layers Analysis

- Jurisdiction
- Interconnection
- Inter-carrier compensation
- Universal Service
- Consumer welfare, safety, accessbility
- New Network investment
- Retail rate regulation

Internet expansion

Internet-enabled Appliances

SIP Telephony

- Session Initiation Protocol Telephones
- Cisco Systems, Pingtel, etc.
- “email” addressing
- ENUM:

1.1.9.3.0.6.5.3.0.7.1.e164.arpa = sip:vinton.g.cerf@mci.com

(any domain name)

NAPTR (naming authority pointer)

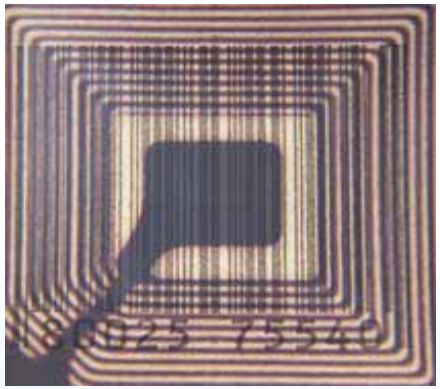
The power of SIP

Videoconferencing online

- Video-conferencing is a reality.
- High speed access is preferable but it can be made to work at dial up speeds (jerkily)
- Many suppliers

RFID

- Toll-Road passive transponder
- Consumer product identifier (like UPC)
- Drug/Food shelf-life and identification
- Patient identification



Internet-enabled Devices

- Programmable – Java, Python, etc.
- Examples:

  WebTV, Palm-Pilot, Mobiles,Video games, Picture Frames, Washing Machines, Surf Board!
- Refrigerator (and the bathroom scales)
- Automobiles (Japan, Germany)
- Internet-enabled wine corks (also note new quantum theory of wine: Schrödinger's wine bottle)
- Internet-enabled socks
- Universal Remote Control

Side Effects of “Free”

- FIDONet (telephone store/forward email)
  - Replaced by wide area, managed services
  - Note similarity to “mesh” networks
- SPAM, SPIM, SPIT

Convergence/Integration

- IP provides transport
  - Real-time and store/forward
  - Latter is just file transfer (any speed)
- Multimedia files – editable objects
  - Standards for interpretation, editing
  - Data type for program invocation
  - User interaction, immersion
  - Platform independence

Smart Media Systems

- Cable, Satellite, Broadcast become file transfer facilities for all digital content
- Ancillary information makes these media data broadcasting carrousels
- Computer screens, PDAs and TVs are display surfaces and interaction tools
- Challenge: getting this architecturally right (clean, structured)

Conclusions

- Telecom (all modes) rapidly changing to be general digital transport service
- Digital media become data types subject to manipulation and control
- IP becomes platform control medium
- Interactive immersion
- User control of scheduling

Cerf's slides and other Internet information can be found at:

www.mci.com/cerfsup

www.isoc.org/internet

livinginternet.com

www.ipnsig.org

www.dtnrg.org