

On the Horizon

Next Generation Networks

DOI Executive Workshop on Enterprise Geospatial Systems

Presented by Charles M. Lee

07/14/2004



A Daunting Challenge

- The audience is smarter than I am ☹
 - Not terribly difficult so don't get too full of yourself!
- The future is hard to predict ☹
 - Where's my flying car?

The 50 Year Game

- Going from 2004 back to 1954
 - What mistakes would we make? Broken noses waiting for doors to open; faucets to run, toilets to flush
- Going from 2054 to 2004
 - Talking to your appliances; automatic personal recognition/configuration (temperature, lighting, music, ambience...)

Growing up fast

- TCP/IP is 30 years old
 - May 1974: “A Protocol for Packet Network Interconnection,” Vint Cerf and Bob Kahn, IEEE Transactions on Communications
 - A copy of this was auctioned for \$3,000 in 2002!
- Commercial Internet is 9 years old
 - NSFnet turned down March 30, 1995

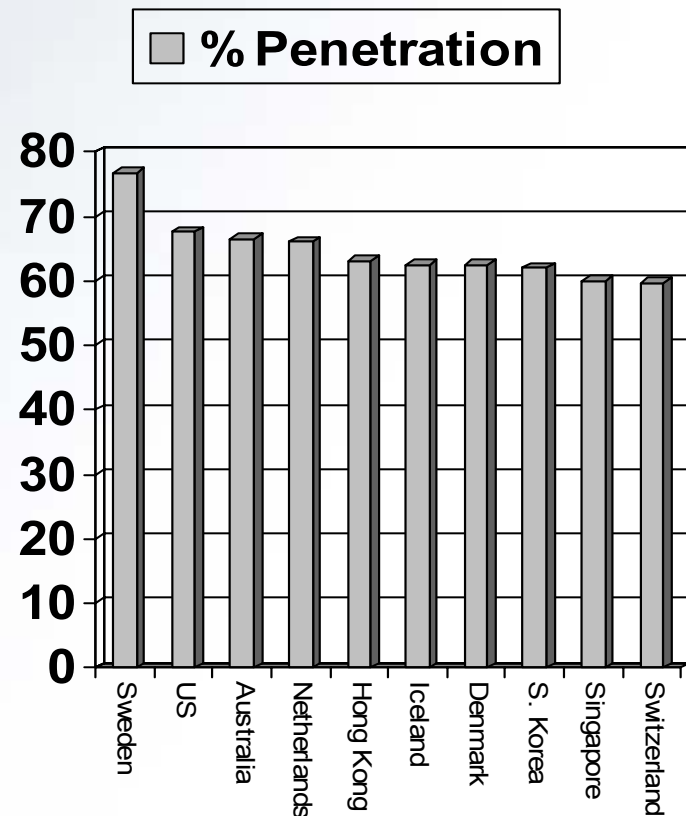
Internet Penetration Statistics

Regions	Pop(2004)	Internet Use (2000)	Internet Use (latest)	User Growth	% Penetration	% of Table	% World Population
Africa	906 M	4.5 M	10.1 M	123.6 %	1.1 %	1.4 %	14%
Asia	3,654 M	114.3 M	235.1 M	105.7 %	6.4 %	31.5 %	56.6%
Europe	729 M	101.0 M	204.6 M	102.5 %	28.1 %	27.4 %	11.3%
Middle East	259 M	5.3 M	14.5 M	174.5 %	5.6 %	1.9 %	4%
North America	327 M	108.1 M	216.0 M	99.8 %	66.1 %	29.1 %	5%
Latin Am Caribbean	546 M	18.0 M	49.5 M	174.0 %	9.1 %	6.6 %	8.5%
Oceania	32 M	7.6 M	15.7 M	105.5 %	49.1 %	2.1 %	0.5%
Total	6,453 M	358.8 M	745.4 M	106.3 %	11.5 %	100.0 %	100%

Highest % Internet Penetrations

- 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)

How the world has changed



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Any comments are welcomed

start

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Internet-enabled Appliances



Internet-enabled Devices

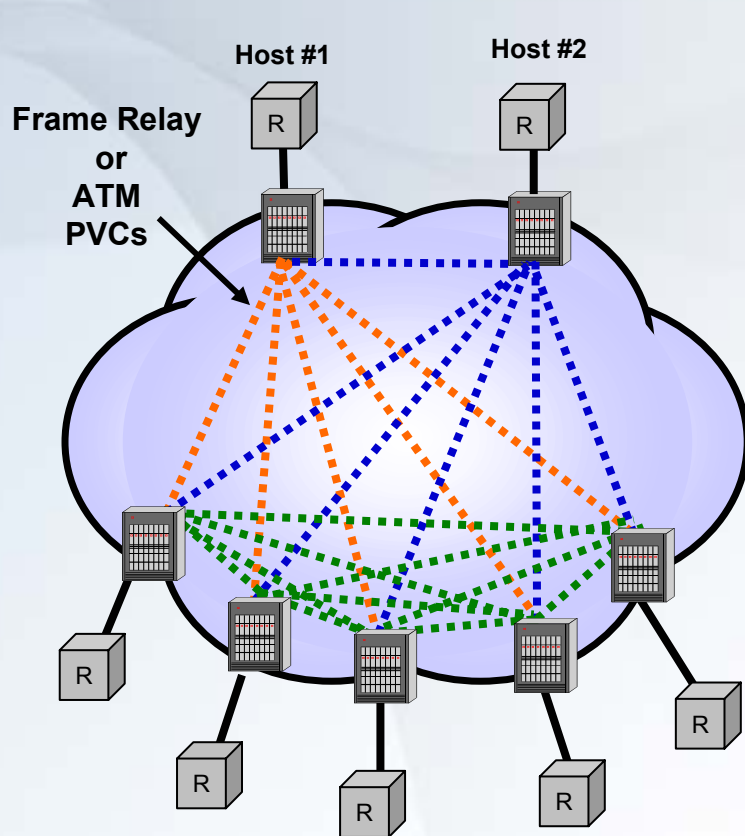
- Programmable – Java, Python, etc.
- Examples:
WebTV, Palm-Pilot, Mobiles, Video games,
Picture Frames, Washing Machines
- Refrigerator (and the bathroom scales)
- Automobiles (Japan, [Netherlands])
- Internet-enabled wine corks
- Internet-enabled socks

Power of IP

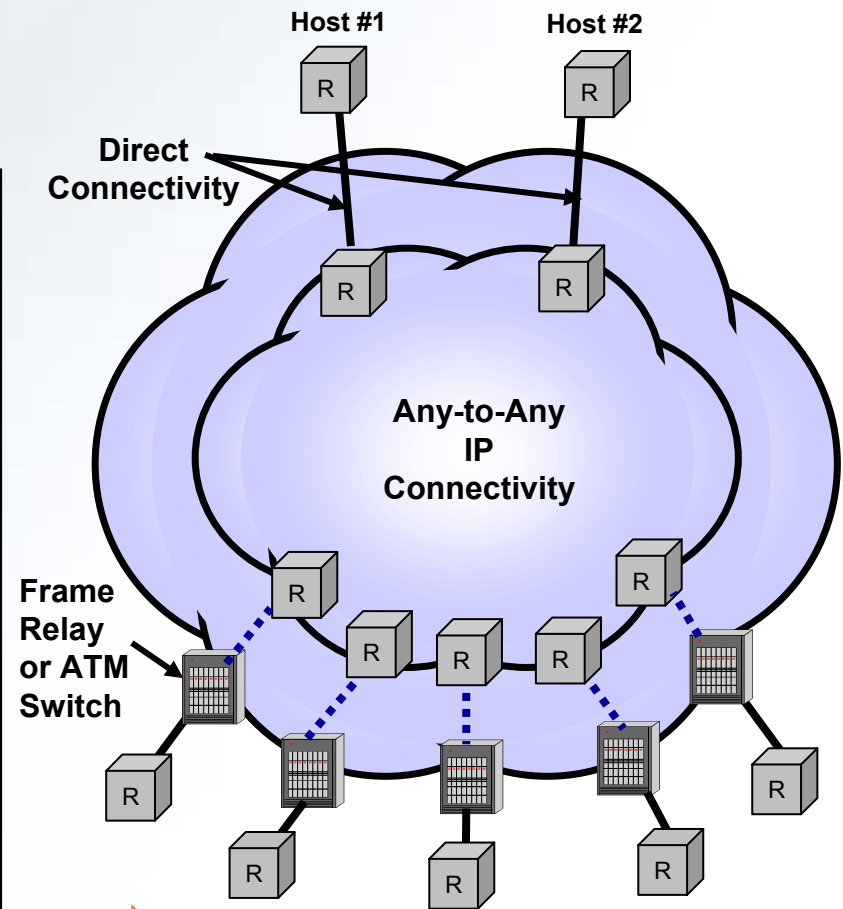
- Layering of Protocols
- IP decouples application from transmission/transport
 - IP does not care what transport is used (satellite, fiber, twisted pair, radio, ATM...)
 - IP does not care what application it is carrying (video, audio, web, email...)
- Profound impact on regulatory models
- Integration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

Why IP for the enterprise?

Cost Efficiencies and Simplification



**Traditional Frame Relay,
ATM or Private Line Networks**



IP Networking

Packet Speech (VOIP)

- Initial ARPANET experiments had packets neither flow controlled nor sequenced
- Duplicated in Internet with User Datagram Protocol (UDP) packets
- Military requirement for voice/data in same network
 - High compression ratio (e.g. 10-to-1)
 - Low bandwidth connections (e.g. 1800 bps)

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)

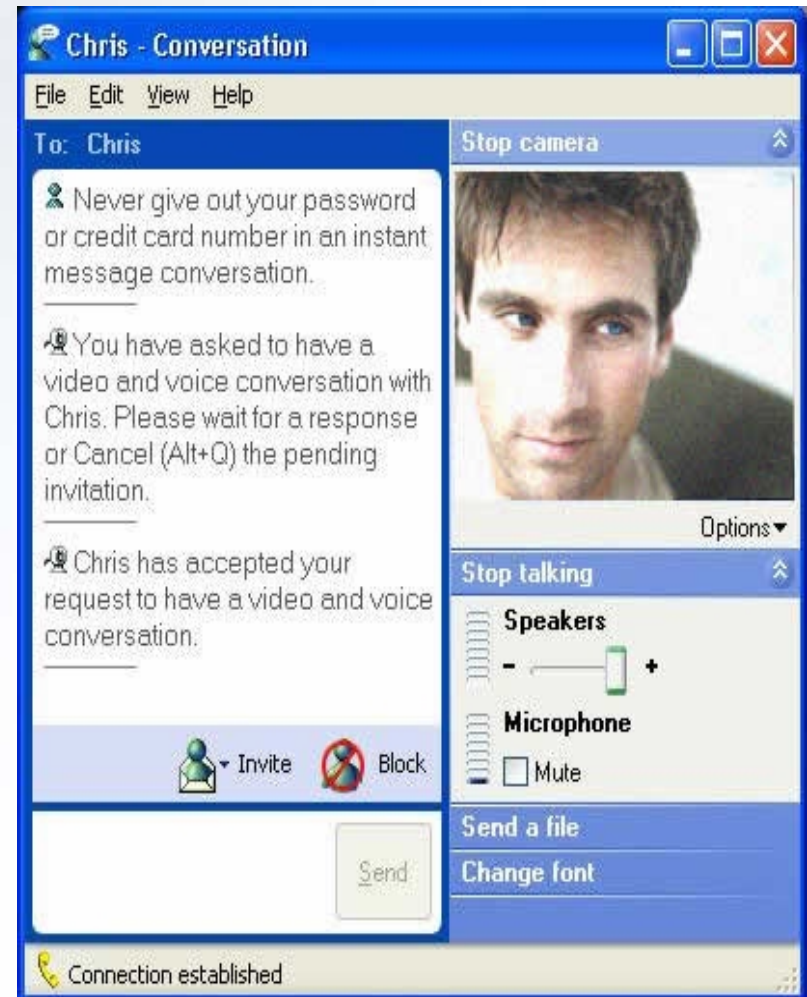
NAPTR (naming authority pointer)

The power of SIP



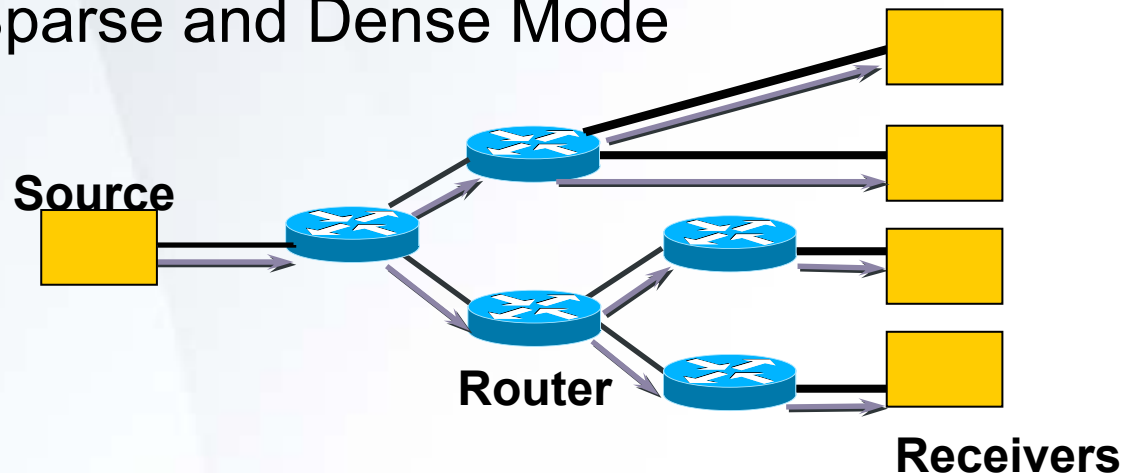
Videoconferencing online

- Video-conferencing is a reality.
- High speed access is preferable but it can be made to work at dial up speeds (jerkily)
- Microsoft Messenger;
Santa Cruz Networks
Viditel



IP Multicast

- Multi-megabit multimedia streaming and large file transfer to multiple sites
- Must be implemented natively in the backbone for scaling and cost efficiency reasons
- Broadcast quality performance the expectation
- PIM Sparse and Dense Mode

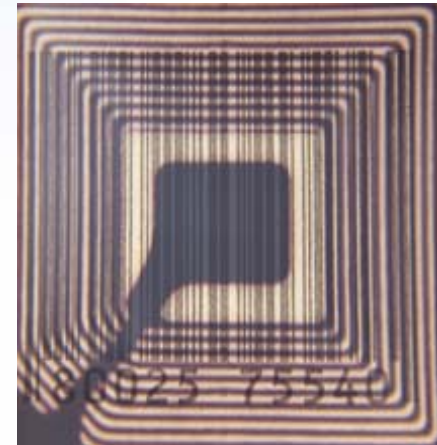


Presence

- Instant messaging
 - First “presence” application
 - Smooth spectrum of communication (text, voice, video, shared applications, group collaboration)
- Presence may vary by application and by community
 - Apparent presence can be tailored
 - Alternative communication media a function of requesting party and medium requested

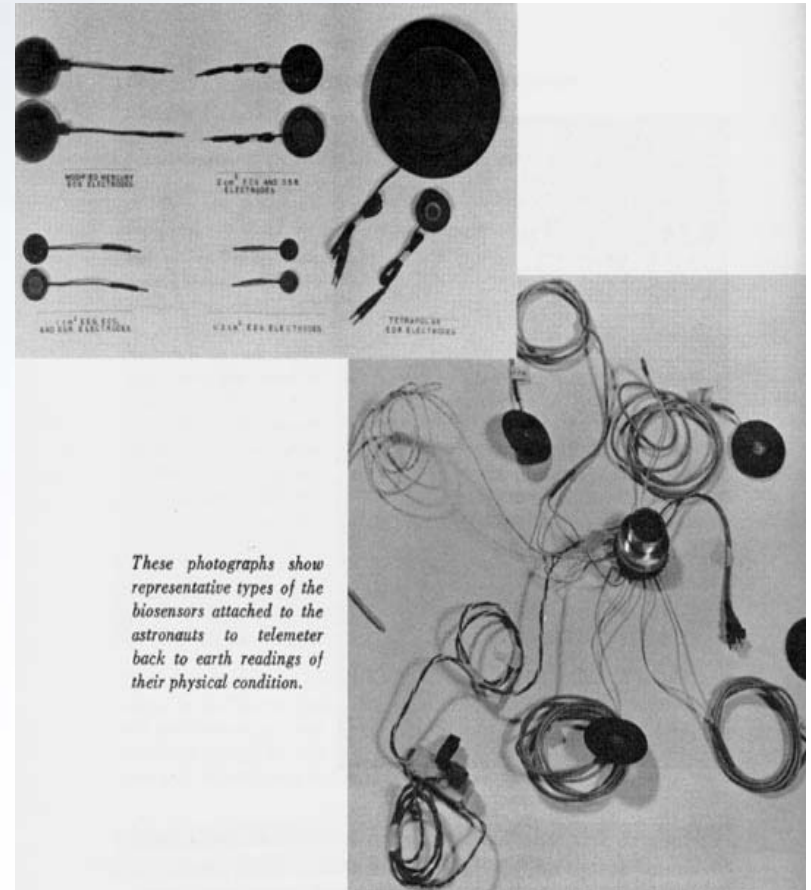
RFID

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



Remote diagnosis/detection

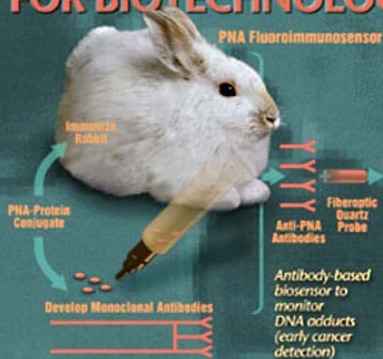
- Astronauts – as far back as the Mercury Program
- Telemetry by radio back to ground data collection systems



Biosensors Today

Oak Ridge National Laboratory

BIOSENSORS FOR BIOTECHNOLOGY



PNA Fluoroimmunosensor

Immunized Rabbit

PNA-Protein Conjugate

Develop Monoclonal Antibodies

Anti-PNA Antibodies

Fiber Optic Quartz Probe

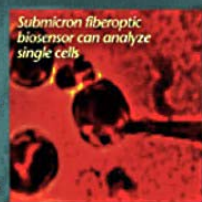
Antibody-based biosensor to monitor DNA adducts (early cancer detection)

Biological Probes

- A new generation of biosensors are being developed, which combine the sensitivity of laser excitation, the versatility of fiberoptics, the low cost of microelectronics, and the specificity of bioreceptor probes:
 - Antibody-based biosensors: detection of attomoles (10^{-18} mole)
 - Gene probes for "Designer Biochips" (e.g., biotests for TB)
 - Synthetic bioprobe (cyclodextrin probes for polyaromatic pollutants)

Advanced Bioinstrumentation

- Laser-based spectroscopies developed for ultrasensitive detection of biological species (DNA, proteins, biomarkers, etc.) using:
 - Laser Synchronous Luminescence: 680 zeptomole (10^{-21} mole) detection limit
 - Surface-Enhanced Raman Scattering (SERS), which enhances up to 100 million times the Raman signals of molecules adsorbed on special SERS probes
- Nanotechnology for biosensors: Submicron fiber optic biosensors (20-nanometer diameter probe) could allow selective analysis of single cells
- Micro-electrooptics, waveguide technology and biological probes are integrated for biosensor development



Submicron fiber optic biosensor can analyze single cells



Fiber optic endoscopic sensor for rapid cancer diagnosis without biopsy

Example of Biomedical Application

- With the Thompson Cancer Survival Center we have recently developed a Laser-induced differential normalized fluorescence (DNF) technique for cancer diagnosis:
 - Rapid cancer diagnosis (0.6 second per measurement)
 - Non-invasive: no biopsy surgery required
 - Performed over 400 measurements for 100 patients
 - Successful test for esophagus cancer: > 98% accuracy
 - Low cost for health care

- This research program involves the collaboration of the multidisciplinary resources of the laboratory: Health Sciences Research, Environmental Sciences, Engineering Technology, and Instrumentation and Control Divisions
- Collaboration with academic institutions and private companies: University of Tennessee, Columbia University, Harvard University, Gamma-Metrics, Environmental Systems Corp., and others

- Non-invasive flow
- Oxygenation levels
- 10^{-18} Mole detection
- DNA array chips
- 10^{-15} sec laser pulse
- Protein marker detection

Wireless Access

- 802.11a,b,g Wireless LANs (“WiFi”)
- 802.16 Wireless MANs (“WiMAX”)
- Bluetooth for local interconnections
- SIP/802.11 telephones, PDAs, tablets, laptops
- CDMA/3G access
- Satellite

Automating Clinical Trials

- Data capture and analysis
- Data reporting
- International operation
- Trial management outsourcing
- Government support (including non-US)
- Important national statistics

Computer-aided Surgery



Robotic Revolution - Device works wonder in prostate cancer surgery.
New York Daily News [read more](#)

- Intuitive Surgical DaVinci system

Security and Privacy

- Tension between these desirable goals
- Vulnerability increases as dependence grows on information technology and computer networking
- Industry needs to take lead in securing systems – technologically and operationally
 - SSL
 - Certificates/PKI
 - USB, PCM/CIA, bluetooth?
 - Identification, authentication, authorization, audit trails
- Individuals also have responsibilities

IP Address Consumption

- Extreme concern in early 90s that IPv4 address space would be consumed within a decade or less
- Led to lengthy IETF work on IPng (next generation).
- Many competing proposals – eventually boiling down to 128 bit IPv6
- Simplification of IP packet format, headers and options

IPv6

- 128 bit address space (10^{38})
- IPSEC requirement
- Eliminates need for Network Address Translation
- Auto-configuration
- Better support for mobility
- Consumer electronics IPv6 enabled
- Dual-stack migration strategy

Major Technology Issues

- Reliability and Availability
- Security of routers, DNS, servers and clients
- Broadband deployment (access, symmetry)
- QOS capabilities (MPLS et al)
- The GRID (virtualization of everything)
- Personal privacy
- Authentication of parties in transactions
- Data integrity and confidentiality
- Deployment of IPv6 standard
- RFID devices

Architectural Priorities

- MPLS traffic engineering
- Multi-label VPN implementation
- Public Internet – another VPN to the underlying MPLS substructure?
- Frame, ATM, IP VPN access to transport core
- Quality of Service (for real time service)
- Wireless access

Networking challenge

- Infinite bandwidth?
 - Terabits for sure (already do 160×10 Gb/s with today's technology).
- Limits are:
 - BFRs
 - Inability to speed up light. (need wormholes and space-time folding here!)
- Packet switching is key.
 - Allows many processes in one machine to communicate with others elsewhere using one high bandwidth link to network.

XML – business processes

- Standard e-reporting formats
- Standard diagnostic formats
- Standard order entry/fulfillment formats
- Standard invoicing/payment protocols
- Automating data collection for statistical purposes – early detection/epidemics
- Target: reduced manual paperwork

Policy Discussion Topics

- Flat rate business models
- Intellectual Property (trademarks, copyright, domain names)
- ICANN: Domain Names, IP Address allocation, dispute resolution
- Online fraud and other abuses
- Censorship (blocking “web pages” and extra-territoriality); geographic independence
- Taxation
- Security and Privacy
- Regulation, broadband, convergence
- Cryptography and export controls

Customer Focus

- Priorities:
 - Customer service
 - Reliability and quality of service
 - Connectivity to the global Internet
 - Voice/Data convergence
 - Inter-enterprise and intra-enterprise communication
 - Telework and roaming support

Questions and Answers