

Internetworking: History & Architecture

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- History and the future
- Internet organizations and resources
- Internet architectural principles
- Roadmap for rest of course

History (1960s)

- 1961: The first paper on packet switching by **Leonard Kleinrock, UCLA.**
- 1962: ARPA computer program begins ...
- 1965: First actual network experiment, Lincoln Labs (now part of MIT) TX-2 tied to SDC's Q32 by **Larry Roberts.**
- 1966-67: ARPAnet program begins
- 1968: **Bob Karn's** team at BBN builds first Interface Message Processor (IMP) later known as a "router".

History (1970s)

- ❑ 1969: **First RFC written**
- ❑ 1970: **ARPAnet spans US (total: ~10 nodes)**
- ❑ 1972: **Email, ftp born (due to *Dave Crocker*)**
- ❑ 1973: ***Bob Metcalfe* at Xerox designs Ethernet**
- ❑ 1974: ***Vint Cerf & Kahn* build first version of TCP, ARPAnet routing is revised**
- ❑ 1977-78: **TCP split into TCP and IP**
- ❑ 1980-83: **ARPAnet splits into ARPAnet and MILNET, and offers software at low cost to universities. NSF invests in CSNET connecting computer science departments.**

History (1980-90s)

- ❑ 1983: **UC Berkeley and BBN integrate TCP/IP into UNIX 4.2 BSD. Berkeley develops network utilities and sockets API.**
- ❑ 1985-87: **Decentralization of naming & addressing. NSF lets regional networks to connect to ARPAnet via a backbone, NSFnet.**
- ❑ 1987-90: **Companies join Internet. EBONE (Europe) connected to NSFnet. TCP improved to handle congestion by *Van Jacobson*.**
- ❑ 1990-93: ***Steve Deering* pioneers multicast and IPv6 work in IETF. *Marc Andresson* writes the first Mosaic browser.**

The 1990s and the future

- ❑ 1993-present: **Internet still grows exponentially. NSFnet is privatized. ATM networks promise new future for backbones. Internet access through telephones, cable, television, and electric companies. ISPs, E-commerce, security, real-time services are the talk of the town. Cisco stock grows 100-fold.**
- ❑ **More: See InternetRevolution.html in course web page (and contribute ideas!)**

Internet Organizations & Resources

- ❑ IAB: Internet Architecture Board
- ❑ IETF: Internet Engineering Task Force
- ❑ InterNIC: Internet Network Information Center (address, domain admin, RFC repository)
- ❑ Resources:
 - ❑ RFCs: <http://www.faqs.org/rfcs/>
 - ❑ Internet Drafts: thru' <http://www.ietf.org/> or <http://info.internet.isi.edu/1/in-drafts/>

Internetworking

- ❑ What is it ?
 - ❑ *“Connect many disparate physical networks and make them function as a coordinated unit ... ” - Douglas Comer*
- ❑ Results:
 - ❑ *Universal Interconnection*
 - ❑ *User interface is network independent*
 - ❑ *All sub-networks are equal in the eyes of TCP/IP*
 - ❑ *Killer apps: Email, WWW*

Internet's Architectural principles

- ❑ *End-to-end principle: (Dave Clark, MIT)*
 - ❑ *Network provides minimum functionality (connectionless forwarding, routing)*
 - ❑ *Value-added functions at hosts (control functions): opposite of telephony model (phone simple, network complex)*
 - ❑ *Idea originated in security: trust the network or the end-systems (what's finally received) ?*
 - ❑ *Beat the X.25 approach: stateful, connection-oriented, hop-by-hop control.*

Architectural principles (contd)

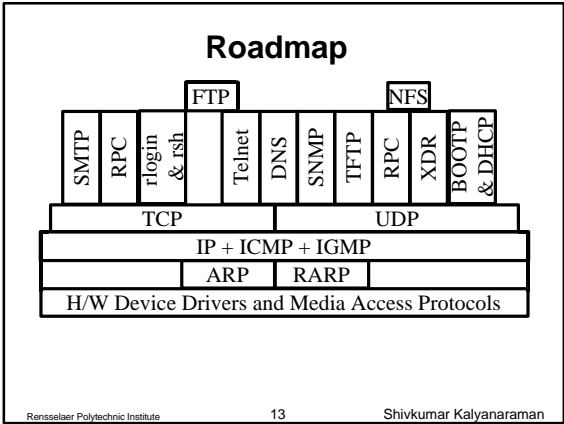
- *IP over everything: (Vint Cerf, VP, MCI)*
 - **An internetworking protocol which works over all underlying sub-networks and provides a single, simple service model (“best-effort delivery”) to the user.**
 - **Translation vs Overlays**
 - **Translation: Eg. Bridges, gateways. Find an identical subset of services and map.**
 - **(+) No software changes in networks required.**
 - **(-) When many networks, subset = 0**

Architectural principles (contd)

- **(-) Translation may be asymmetric**
- **Overlays: Eg. IP. New protocol which runs over all underlying networks.**
 - **(+) IP was simple & required only a small set of services from underlying technology (forward, broadcast)**
 - **(+) Addressing unique, user interface uniform**
 - **(-) May stifle the capabilities of underlying networks which may allow richer service models (eg: ATM)**

Architectural Principles (Contd)

- *Connectivity is its own reward:*
 - **The more the users of the Internet, the more valuable it is.**
 - **Pragmatic design:**
 - **Support all platforms, all kinds of users.**
 - **“Understand/receive as many formats as possible; send using a standard format”**
 - **Build *de facto* standards: requires rough consensus and running code. Anyone can participate in standardization.**



Summary

- History and future
- Internet organizations and resources
- Internet architectural principles
- Roadmap

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Informal Exercise

- The VC approaches pioneered by telecom industries trying to get the edge in data networking (X.25) lost to IP. But they are in the form of ATM. Why is VC still an idea that makes market sense?
- Can you dream up a product (like Cisco's router in the 1990s) which will drive and thrive in the Internet spotlight ?
- Read ahead appendix A, chap 3.
- Long term reading (for Quiz 1): RFCs 1122, 1123, 1812 (host, router requirements)

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