

Arriving someplace in a roundabout way

Scott Bradner
Harvard University

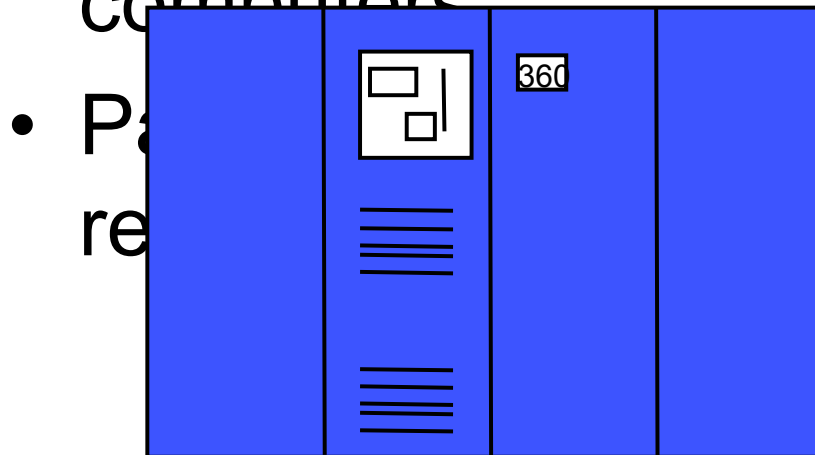
Before the Beginning

- **The Phone Network from The Phone Company**
- circuit-based
- predictable interconnections between ends
- assumed absolute requirement for QoS
- assumption of being carrier-pro
- the (or e was voice

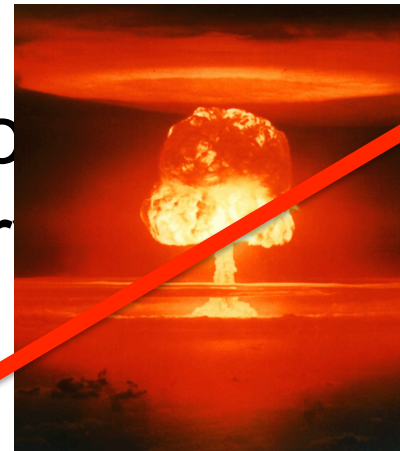


The Beginning, 1960s

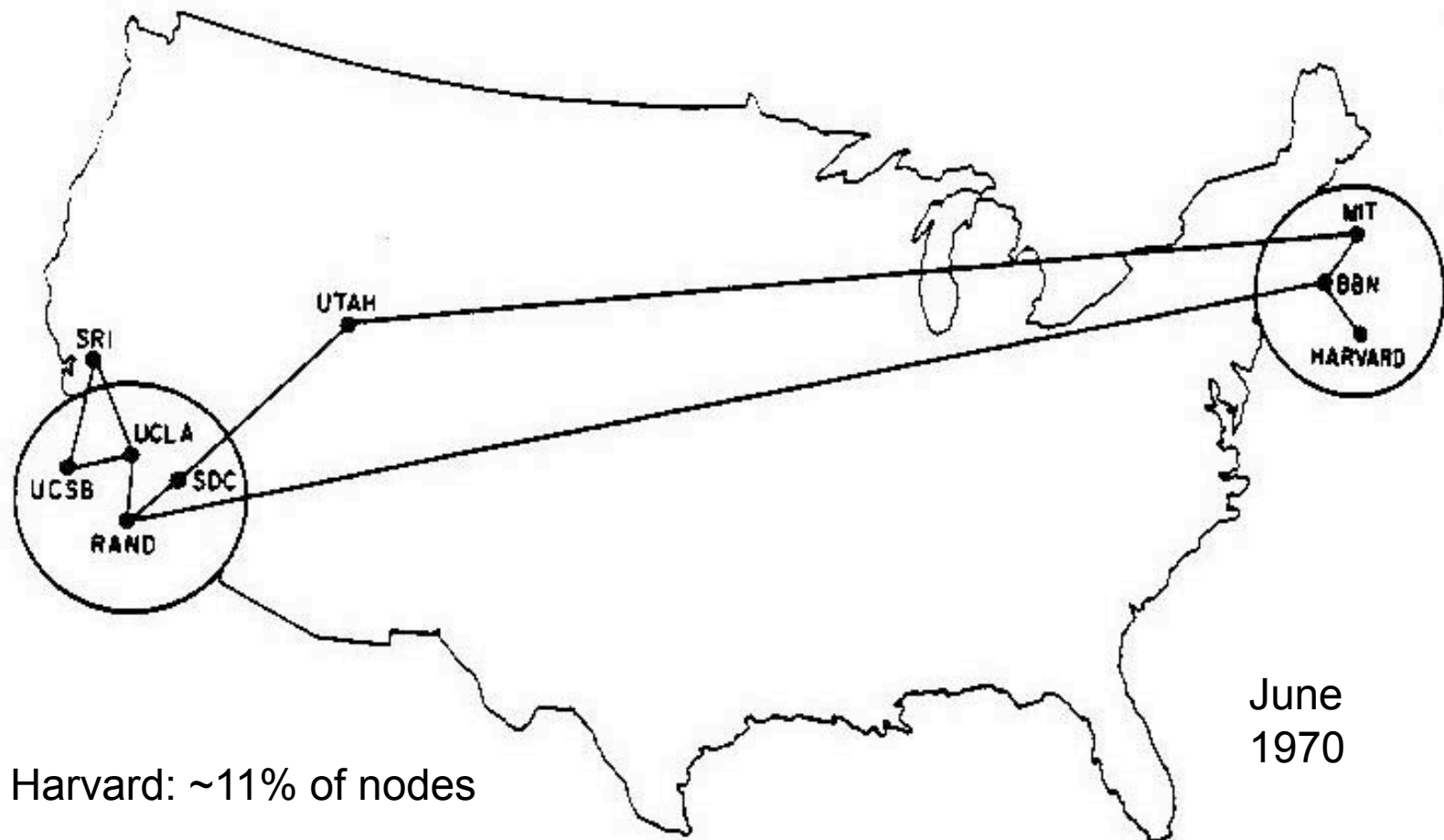
- Len Kleinrock: packet-based networks work
- JC Licklider: global data networks imaginable
- Larry Roberts: need to share scarce computers



port network
way, sur



First Contact



A Rider Not a Builder

- The ARPANET, and the follow on Internet, rode on the telephone network
 - But were not services offered by the telephone companies
 - Internet service providers (ISPs) bought “wires” from telephone companies
- ISP routers interconnected these wires
 - ISPs not limited to a single telephone carrier or to a single country

The View From Most of Harvard

Why Blank?

- No internal Harvard network

But, so what – the ARPANET was between a computer at a site to a computer at another site

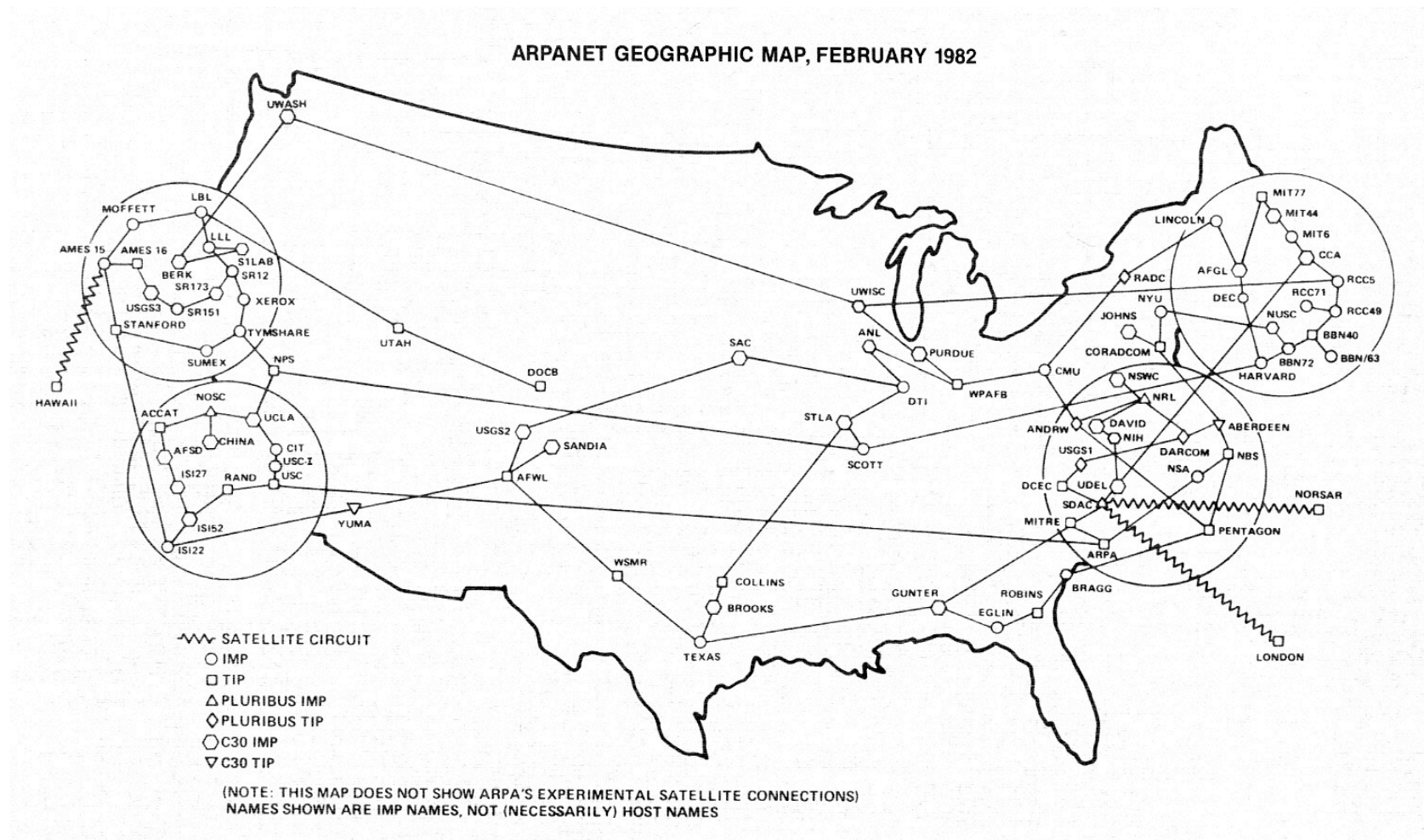
- No permission

Only people getting federal funds were permitted to use the ARPANET

And staff on the connected computer :-)

- Thus, very small percent of the Harvard community knew about, or used, the ARPANET

The View Changed in 1983

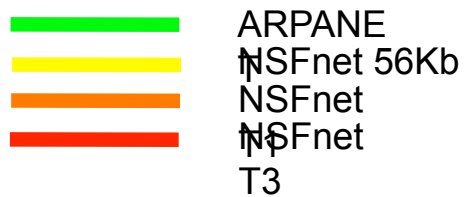
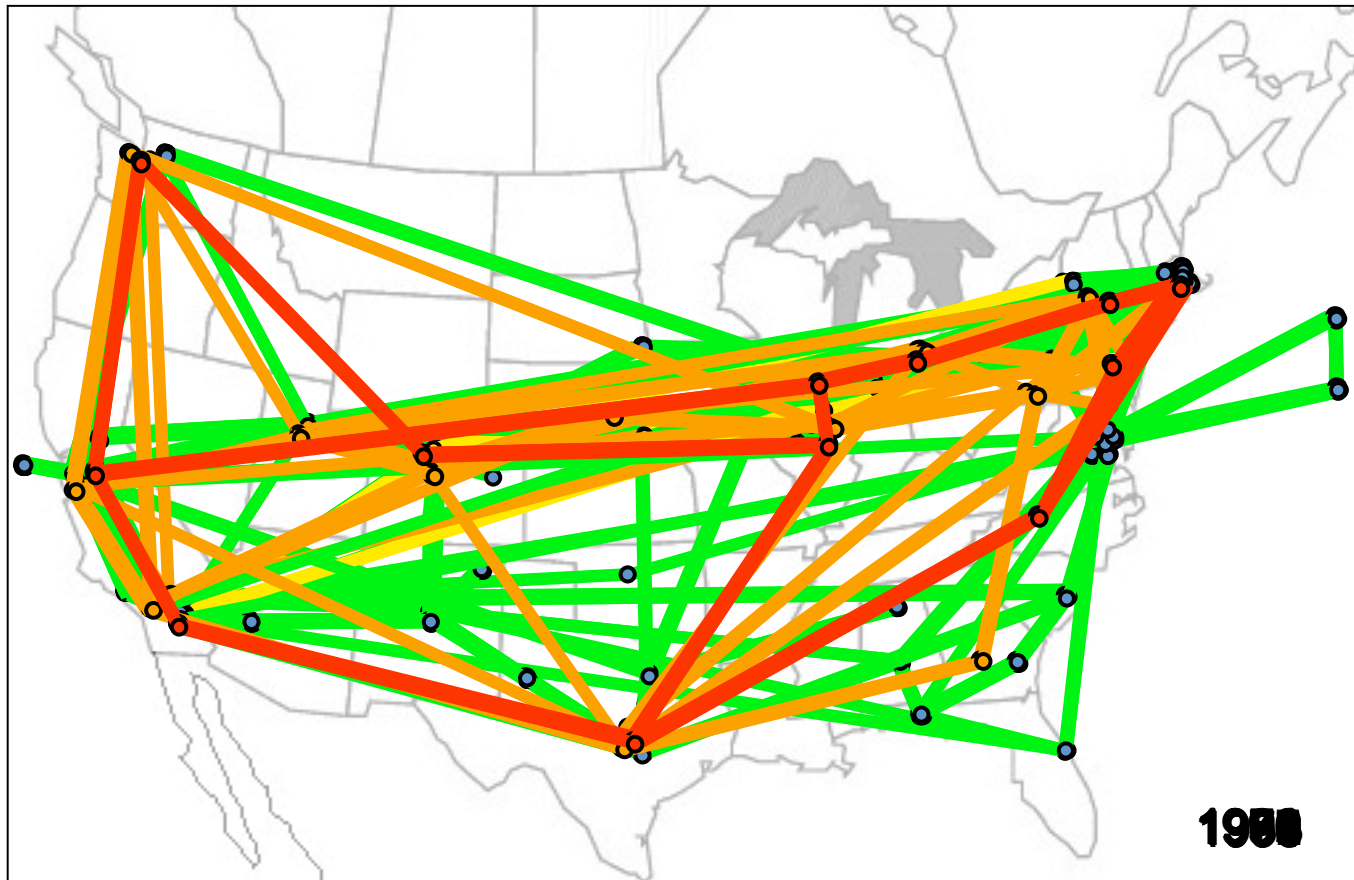


ARPANET view Enabled by
CSNet

Two Changes in 1983

- CSnet membership gave blanket access permission (for email)
 - Including all faculty, students and staff
 - Exposing the first of many generations of students
- Deployment of TCP/IP
 - Change to interconnecting networks at sites
- Started & proven by the feds, who then fade

Federal Net Topology



What Did They Prove?

- That high-speed packet-based networks could be built and operated reliably
- That packet-based network were useful
- That packet-based networks could support many services

Me @ Harvard

- ARPANET #1: sob at harv10
- NIC: SB28
- Usenet: {genrad|bbncca|panda|ihnp4|allegro|harvard}!wjh12!sob
- BITNET: sob at HARVUNXW
- ARPANET #2: sob@harvard.harvard.edu
- NSFNet: sob@harvard.edu

History Feature: Bang Addressing

- Usenet (uucp) initially ran over dial-up connections between routers
 - Cost hidden in coms budget
- Uucp used source routing
- Sender defined store and forward path to reach destination
- Exclamation points (bangs) between node names

How Not to Do it: Pathalias

- Pathalias discovered uucp paths to destinations
- Worked off of a map of uucp nodes and connections
- Uucp mapping project started in early 1984 to create a whole-world map of uucp nodes
Unknown Mailer Error 101, or Why Its So Hard To See You – USENIX summer 1984
- Project closed in 2000, OBE

History Feature: BITNET

- Because Its There Network
Later changed to “Because its Time”
- Interconnected IBM mainframes
And machines that pretended to be IBM mainframes
- Store & forward, world-wide
- Like uucp, costs buried in telecom bill
Avoided having to get permission

Harvard and Internet #1

- Initial IP external connectivity via ARPANET
 - To one or two computers in Aiken Comp lab
- Internal connectivity by point-to-point twisted pair cables
 - Up to 1.5 Mbps
 - Running SLIP

Gateway

- Wjh12 (an 11/44) served as a gateway between BITNET, usenet & ARPANET
And the Harvard campus
- The first time I heard “do not ask questions you do not want to know the answers to”
When I asked if it was OK to take over the Usenet/ARPANET gateway function from Larry Landweber

Internet Moves to Be All

- Both uucp & BITNET evolved to run over TCP/IP

Then died

- Chaosnet, XNS, IPX, DECNET, AppleTalk, SNA, APPN bloomed, then withered, then died – leaving only TCP/IP

- VoIP not new

Danny Cohen: Network Voice Protocol (RFC 741 1977)

- Nor is video

Van Jacobson et al, Whiteboard (1992)

Harvard and Internet #2: 1986

- Internal fiber Ethernet – 13 buildings
Passive optical
- External - John Von Neumann Computer Network (JvNCnet)
NSF-funded network to connect to
supercomputer
T1 to MIT & then T1 to Princeton
- NSFNet v1 (56 Kbps) interconnected
supercomputer centers

Harvard and Internet #3: 1988

- We can do better: NEARnet
- MIT-, BU- & Harvard-founded regional network
 - New England area
 - 10 Mbps microwave Ethernet
 - BBN hired to manage
- Some DARPA funding, so they could end ARPANET – no NSF funding
- No rule against commercial traffic
- Connected to CIX (not just NSFnet)

10 Decisions That Made a Difference

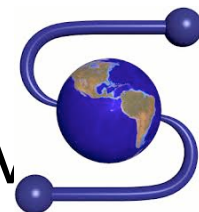
- support existing networks
- datagram-based
- creating the router function
- split ITCP into IP and TCP
- DARPA fund Berkeley to add TCP/IP to UNIX
- CSNET and CSNET/ARPANET deal
- NSF require TCP/IP on NSFnet
- ISO turn down TCP/IP standardization
- NSF Acceptable Use Policy (AUP)
- minimal regulation

Enabler, Not Inventor



- High Performance Computing Act of 1991 (HPCA)

Funded research centers and connectiv



Commercial Internet

- Forced by ARPANET & NSFnet AUPs
- UUnet – 1987 (loan from Usenix) **USENIX**
- PSInet – 1989
- ANS – 1990 (ANS CO+RE 1991)
- ...

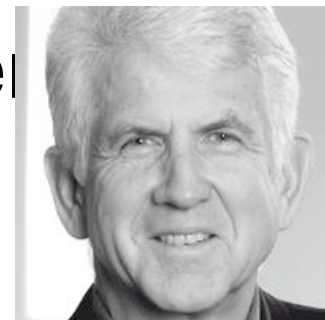


Friends And Family (only)?

- ‘I will not interconnect with him’



- Also Prodigy, AOL, CompuServe
- Isolation did not last



But, Inconceivable Relevance

- Existing telecommunications world did not believe

E.g., IBM no-bid ARPANET router
no future in packet-based networks

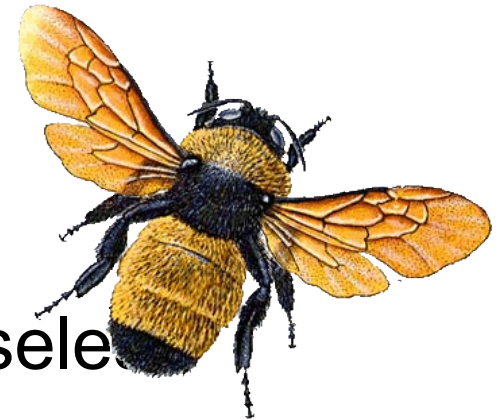
Conventional wisdom: best effort use

Guaranteed QoS required

Most connections low speed (dial-up)

No threat seen to telephone companies

- Thus, totally ignored by regulators
including the ITU

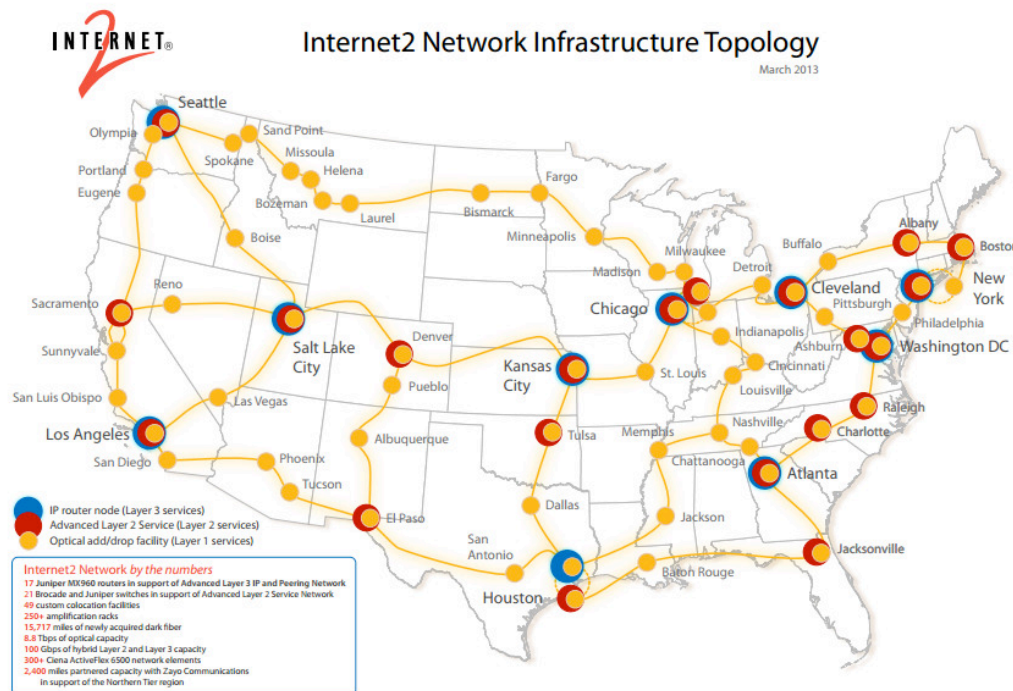


Many Non-Believers

- Harvard library: refused to put card catalog on-line
- Network World: discouraged me from writing about the Internet until the late 1990s
- ITU-T spent a decade working on NGN
- Regulators assumed uselessness so ignored the Internet until recently

Internet2: A Non-Alternate Universe

- Born from MFUG in 1996
- ‘High-speed, QoS & GigaPOPs’
- ISP for high-ed+, COTS equipment



Side Trip (So Far)

- It is now 20 years since IPv6 was announced
IETF 30, Toronto CA July 1994
ALE WG: v4 addresses to run out 2008 \pm 3
- Yes, we have no (v4) addresses: IANA (2011)
Ditto APNIC (2011), ditto RIPE
LACNIC: (projected 2014)
ARIN: (projected 2015)
AFRNIC: (projected 2019)
- Few choices but v6, but ...
Delaying by using a address market



The Now Reality

- Its only IP for transport
voice, video and other types of data
- Carriers, not ISPs, for residential market
- Little competition
- Much money made using the Internet, not so much providing the Internet
- Now the FCC wants to replace what got us here
- The net is too important to leave it to the people that know what they are doing



Higher Ed and the Internet

- Without higher-ed the Internet would not have become **The Internet**
- Exposed students & others to the power of open communications – creating demand
- Implemented ideas when they were new (e.g. WWW)
- Supported ISPs (rather than carriers wanting a walled garden with a per-port fee)

A Fun Ride

- From geek-bait to mom-surfing
- From aggressively ignored to can't take their hands off it
- From rot-13 for sensitive eyes to decimating the porn industry
- From pushing green cards to 70% spam
- From naïve libertarians to the Arab Spring
- From the Cuckoo's Egg to NSA world-Hoovering

I hope we recognize what comes out
of the next phase