CSNET

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November 29, 2007

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CSNET Goals

In 1980 very few computer scientists were using computer networks, even for email. CSNET's goals were

- To provide the benefits of the Internet to all US computer scientists
- To demonstrate that networking services would be valued by users
- To build a foundation for extending the Internet to all of academia and beyond

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CSNET Beginnings

- May 1979: Larry Landweber invites small group including Kent Curtis (NSF) and Bob Kahn (DARPA) to meet in Madison
- 1979-80: Group of universities iterates on proposals to NSF – first one is rejected, the second is funded after several revisions
- January 1981: NSF provides $5 million for five years to Delaware, Purdue, RAND, Wisconsin. First large-scale networking project funded by NSF
- June 1982: Coordination and Information Center (BBN)
- December 1983: Management contract (UCAR)

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Characteristics

- Low membership fee for academic departments
- Fee for communications services (Telephone, leased 9.6Kbps for IP/X.25)
- Subsidized by industry membership fees ($25,000)

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Characteristics

- NSF required attainment of financial self sufficiency
- DARPA agreement enabled unique charter for international connections (13 countries)
- Peak membership included most PhD granting CS depts plus industry and government labs (165)
- **FIRST USE OF A COMPUTER NETWORK FOR MOST USERS**

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The Technology

- Phonenet – MMDF Mail Relay (Delaware)
- IP over X.25 - Telenet (Purdue)
- Nameserver for Email (Wisconsin)
- Operations / gateway / mail relays (BBN)
- Logical network: Telenet, Arpanet, Phonenet, Relays and Gateways

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NSF Review Comments

- TCP/IP
  - “will set a defacto standard that may be inappropriate for networking”
  - “puts a relatively complex and CPU intensive load on hosts”
- Scale
  - “if CSNET membership is open, the network could/will be taxed beyond its theoretical limits”
- Cost
  - “how many schools can afford $12-16 thousand on top of their present computer costs”

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CSNET's Contributions to the Development of the Internet

- *Community*: CSNET made it possible for all US computer researchers in academia and industry to have access to network services.
- *Protocols*: Adoption of TCP/IP helped accelerate acceptance of the Internet protocols.
- *Sustainability*: CSNET demonstrated that computer scientists would divert resources to pay for network services thereby meeting NSF's requirement that it become self sufficient.
- *Partnership*: CSNET pioneered the university-industry-government partnerships that characterized future US networking projects.

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CSNET's Contributions to the Development of the Internet

- *International*: CSNET helped spread networking around the world by advising / collaborating with groups in other countries and making available CSNET-developed technology for connectivity to the US.
- *Policy:* CSNET negotiated key policy decisions that opened the network to commercial and international participation..
- *Bridge to Today's Internet*: CSNET was critical in the transition from the pre-1980 world of small research networks to the post-1980 Internet.
- *Proof of Concept*: The experience with CSNET enabled NSF to confidently undertake NSFNET, the initial backbone of the modern Internet.

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BITNET

November 29, 2007

Kenneth M. King

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BITNET Origin

- Ira Fuchs letter to 50 Universities March 1981.
- Yale connects to CUNY September 1981.
- Because it's There net evolves into Because it's Time net.

The Technology

- RSCS on IBM mainframes and Vax VMS.
- Store and forward file transfer system.
- A tree structure network.

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Rules for Membership

- You must be an Educational Institution.
- Provide two modems and a 9600 full duplex leased line to a Bitnet node.
- Agree to provide at least one port to a new member
- Agree to pass traffic for downstream nodes without chargeback.

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BITNET's Goal

- To connect every scholar in the world to every other scholar.
- BITNET supported:
  - all disciplines,
  - all countries,
  - faculty, students and staff.

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BITNET Services

- email
- List Management i.e. Listserv (a first)
- chat (instant messaging)
- BITFTP
- email connection though gateways to other networks.
- 30% discount on Cisco routers to BITNET members 1985.

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BITNET's Reach

- Merged with CSNET in 1989.
- Grew to connect 500 institutions in 49 countries.
- First connection to the Soviet Union 1990.
- About 1400 nodes.

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BITNET's Contributions to the Development of the Internet

- BITNET's goal became the first of four academic goals for the Internet.
- BITNET played a major role in convincing Universities of the value of networking.
- BITNET contributed significantly to the building of campus local area networks and support staffs.
- BITNET members and campus supercomputer users spearheaded the development of regional networks.

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BITNET's Contributions to the Development of the Internet (continued)

- A number of technological innovations including list management, chat, multi user network games, internet dating, and the first pandemic virus.
- BITNET contributed to the growth of interuniversity scholarly collaboration.
- Dennis Jennings

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Looking backward – the transition to NSFNet

Distinguished Career Professor of
Computer Science and Public Policy
School of Computer Science
Carnegie Mellon University

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Where did CSNet leave us

- An operational email system reaching most CS departments and key industry research labs.
- Limited (because of cost and technical limitations of Telenet) use of IP over X.25.
- Spreading international connectivity
- An increasing demand from industry for access
- A change in the computer scene

And most important, a demand from computer scientists and other parts of the University for full Internet services

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Too many disconnected facilities

- CSNet, Bitnet, Arpanet ..
- The need for one concept for the expansion of network services under one protocol
- The beginning of the getting together
- Farber, Landweber, Kuo initial ideas for “ScienceNet”

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The fight over protocols

- OSI vs Decnet vs TCP/IP
- DoD
- NRC

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The decision to go forward

- Getting a Program Manager
- Selling the idea to “Science”
- Setting up a real NTAG

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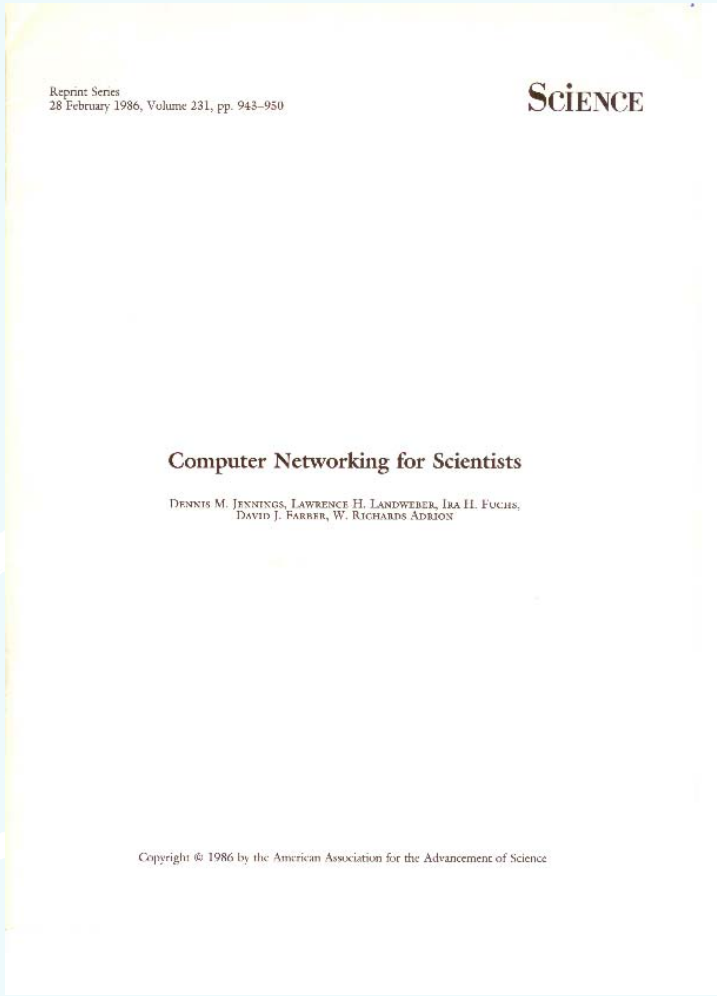
The Science Paper

- Computer Networking for Scientists
  - Dennis M. Jennings
  - Lawrence H. Landweber
  - Ira H. Fuchs
  - David J. Farber
  - W. Richards Adrion



Reprint Series
28 February 1986, Volume 231, pp. 943–950

SCIENCE

Computer Networking for Scientists

DENNIS M. JENNINGS, LAWRENCE H. LANDWEBER, IRA H. FUCHS,
DAVID J. FARBER, W. RICHARDS ADRION

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The Science Paper Vision

- “NSFnet is expected to be a general-purpose communications network for the whole academic research community and associated industrial researchers”.
- “Our vision of this network is of a vast network of networks interconnecting the scientists local advanced graphics workstation environment to other local and national resources”.
- “Through that single window the scientist may gain access to required computing facilities and databases and communicate with peers, colleagues, and scholars throughout the world”.

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Supercomputing
And
TCP-IP

Kenneth Wilson
The Ohio State University
Formerly: Head of the
Cornell Theory Center

Nov. 29, 2007

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Theory Center Dream

UNIVERSAL Remote Access to Parallel Processing

Supercomputers with COLOSSAL computing power

(Not achieved yet, NOT EVEN TODAY!)

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Our Reality:1985-1987

IBM mainframe with attached processors

Users on DEC equipment

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Orders from my Staff

When in meetings in Washington:

Pound the table for TCP-IP

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NSFNET
Policy, Model, Decisions

Dennis Jennings

NSF Program Director for Networking

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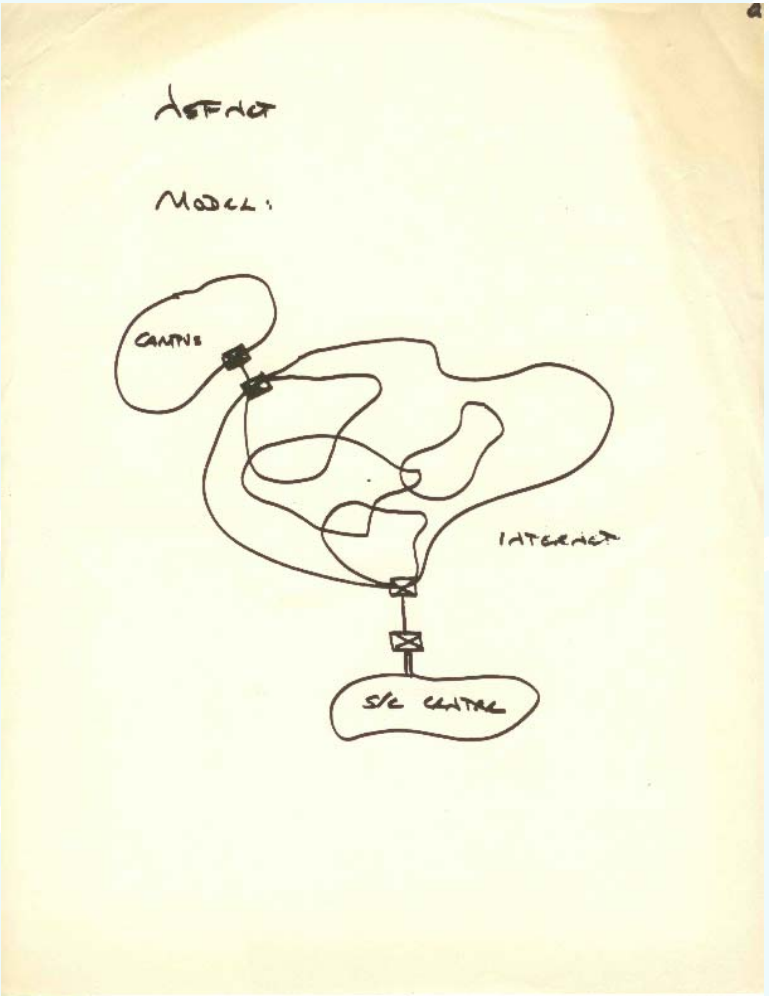
Policy - Model

- Build a Supercomputer Access Network
- Presentation to National Science Board
  - Not a single network
  - A network of networks
  - An Internet

    (January 1985)



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NTAG
Network Technical Advisory Group

- Dr. Henry D. Dardy, NRL
- Dr. Peter Denning, RIACS
- Dr. David J. Farber, U. Delaware (Chairman)
- Dr. A. Frederick Fath, Boeing
- Dr. Alexander G. Fraser, Bell Labs
- Dr. Ira Fuchs, CUNY
- Dr. Lawrence Landweber, U. Wisconsin
- Dr. Anthony Lauck, DEC
- Dr. James Leighton, Livermore Labs
- Dr. Barry Leiner, DARPA
- Dr. David L. Mills, U. Delaware
- Dr. Harvey Newman, CALTECH
- Dr. Dennis Jennings, NSF
- Dan Van Belleghem, NSF

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Policy – Key Decisions

- A General Purpose Network
- An Internet
- TCP/IP
- Enforce TCP/IP

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Model – Key Decisions

- A Three Tier Network
  - Campus Networks
  - Regional Networks / Community Networks
  - National Backbone

    ARPANET Expansion

    New National Backbone

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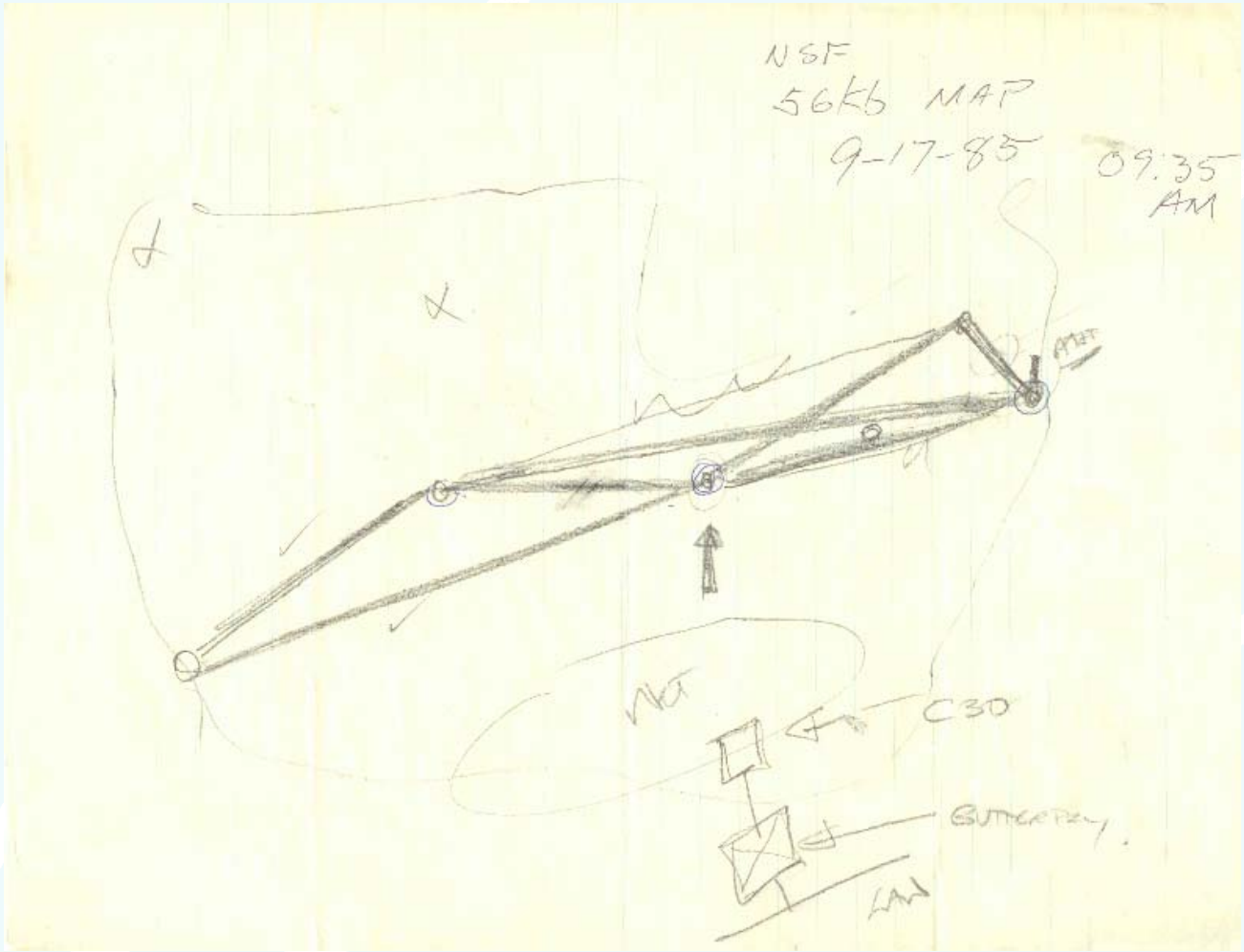
The (interim) Backbone



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Backbone – Policy Decisions

- A Standard Router
  - To develop a specification for a standard router (RFC985).
- To Switch IP Packets
  - To eliminate X.25 level 3 packet switching
- The Fuzzball
  - To use an interim router solution (Dave Mill's Fuzzball) for the NSFNET backbone to permit the industry time to develop routers that met the standard router specification.

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Communication

- Communicating the NSFNET Vision
  - Presentations
  - Debates (TCP/IP v. MFEnet v. DECnet)
  - Arguments / Persuasion
  - Funding – The Golden Rule
  - Publication – The Science Paper

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The NSFnet Phase-I Backbone
and
The Fuzzball Router

David L. Mills
University of Delaware
29 November 2007

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NSF 1986 Backbone Network

- The NSFnet phase-I backbone network (1986-1988) was the first large scale deployment of interdomain routing and autonomous systems
- Five NSFnet backbone routers exchanged backbone and campus routes using the Hello intradomain protocol
- Campus sites exchanged campus and ARPAnet routes using the EGP interdomain routing protocol
- See Mills, D.L., and H.-W. Braun. The NSFnet backbone network, *Proc. SIGCOMM 87*

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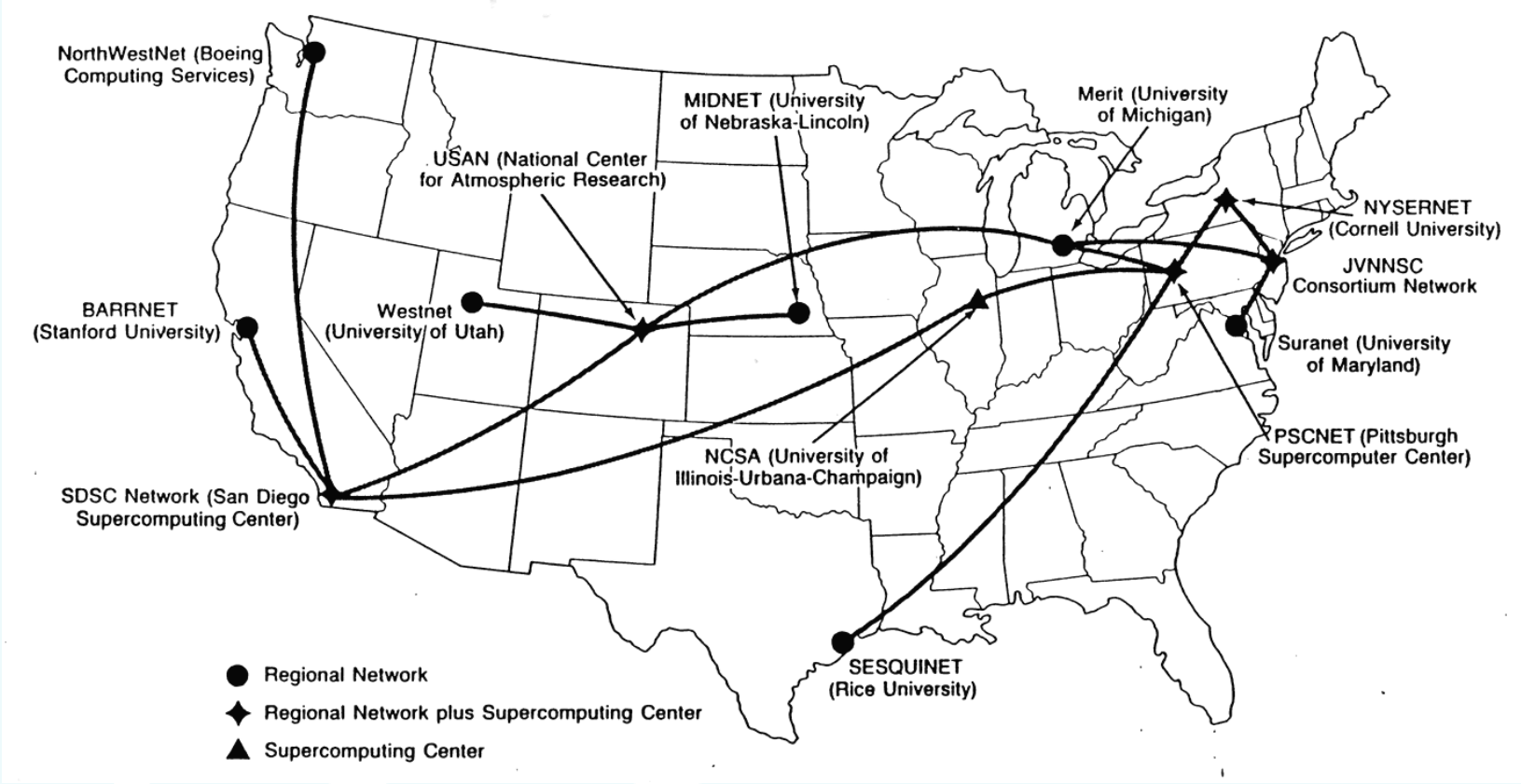
NSFnet 1988 Backbone Topology



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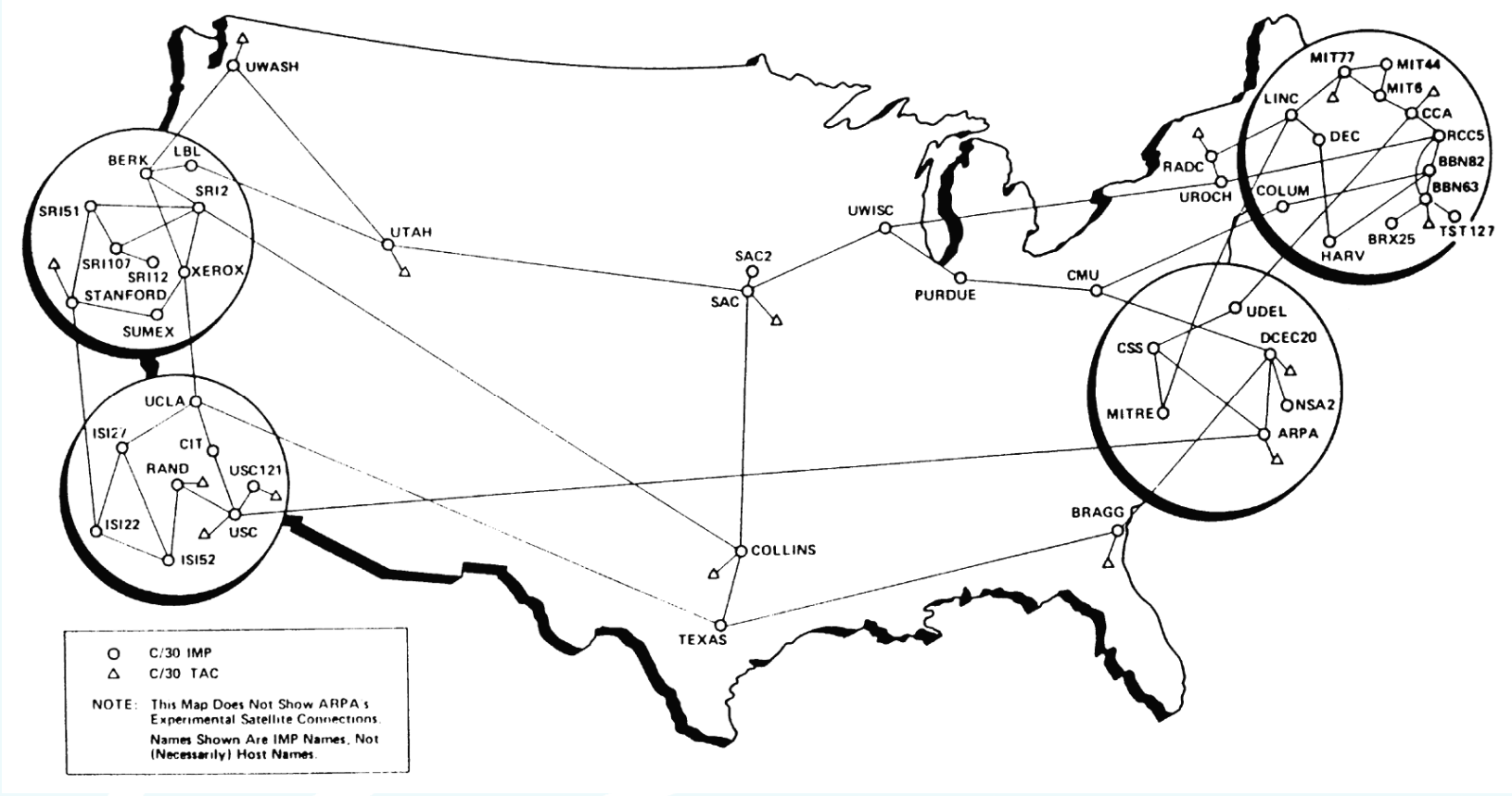
ARPAnet Topology August 1986



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Evolution to Multicore Routing

- NSF cut a deal with DARPA to use ARPAnet connectivity between research institutions until a national network could be put in place
- The Internet routing centroid shifted from a single, tightly managed system to a loose confederation of interlocking autonomous systems
- There were in fact two core systems, the ARPAnet core and NSFnet core
- The NSF core consisted of Fuzzball routers at the six supercomputing sites and a few at other sites
- Other systems played with one or both cores and sometimes ignored the inconvenient rules

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The Fuzzball

- The Fuzzball was one of the first workstations designed specifically for network protocol development, testing and evaluation
- It was based on PDP11 architecture and a portable, multiple-process, virtual operating system
- They supported all Internet protocols of the day, including Telnet, FTP, mail, fax and voice
- They were cloned in dozens of personal workstations, gateways and resource servers in the US and Europe

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Mommy, what's a Fuzzball?

- Left: First Fuzzball 1978
- Right: Last known Fuzzball, now in my basement
- See Mills, D.L. The Fuzzball, *Proc. ACM SIGCOMM 88*

The Fuzzball as NSFnet Router

- NSF held a backeoff in 1985 with Cisco, Proteon, BBN and Fuzzball, or three tigers and a kitten
- Fuzzball won, not because it was cute and cheap, but it was 30 times faster than the then current BBN ARPAnet gateway
- NSF bought five of them with 1 MB of RAM, dual floppy disks(!) and really evil communication coprocessors that caused serious problems later
- DARPA bought four WWVB receivers and the Fuzzballs became the first NTP time servers

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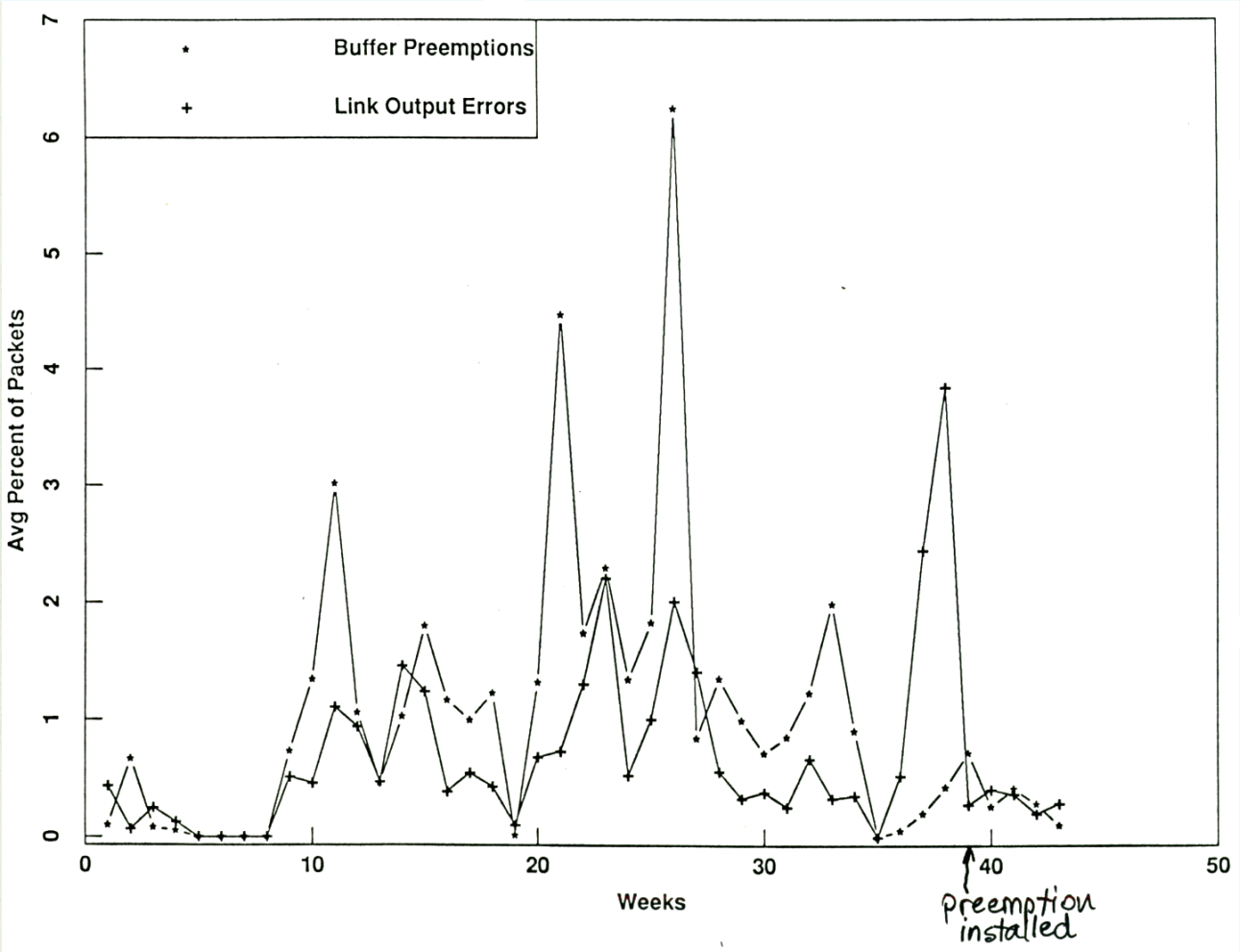
Panic and Mischief

- The network became gloriously overloaded; Dennis and I hatched desperate countermeasures,
- Priority queueing favored real-time Telnet customers while punishing FTP and mail
- Elephants (with lots of packets) were preempted until all customers received equally ugly service
- ICMP Source Quench really worked sometimes
- The real problem was buffer lockup in the communications coprocessors and the network did at times degenerate to total congestion collapse

Selective Preemption Strategy



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Lessons from the Early NSFnet

- Shooting the elephants until the forest is safe for mice was the single most effective form of congestion control
- Managing the global Internet could not be done by any single authority, but of necessity must be done by consensus between mutual partners
- Routing paradigms used in different systems can have incommensurate political and economic goals and constraints that have nothing to do with good engineering principles
- The Internet cannot be engineered – it must grow and mutate while feeding on whatever technology is available

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