6.829 Computer Networks

Lecture 1

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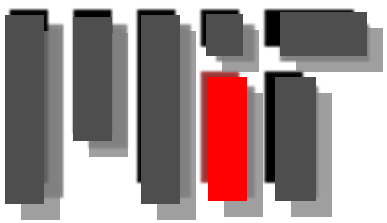


Slides use info from Hari Balakrishnan and Nick Mckeown

Staff

- Instructor
  - Dina Katabi dk@mit.edu
- TAs
  - Sachin Katti skatti@mit.edu
  - Rob Beverley rbeverly@MIT.EDU
- Guest Lecturer
  - Dr. Bruce Davie, Cisco

What is this class about?

- Understand how networks work
- Think how to improve current networks

Class

- Webpage http://nms.csail.mit.edu/6.829/
- Signup sheet
- Pre-reqs:
  - 6.033 or an undergraduate networking class
    - IP,TCP, routing, Ethernet, packets
- Course Material
  - Lecture Notes/Slides
  - Research Papers
  - Recommended Book "Peterson & Davie"

Grading

Project	40%
2 Quizzes	40%
HW	15%
Participation	5%

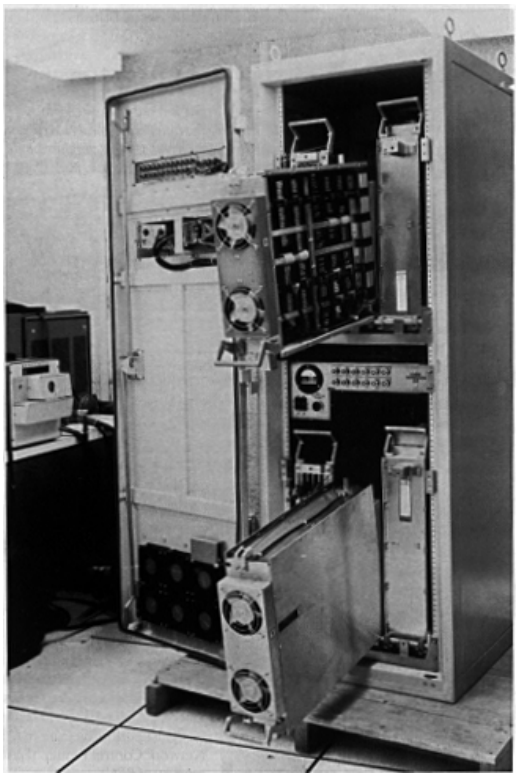
Project groups are 2-3 students. Proposal discussion is on 9/22

Questions?

Who invented the Internet?

- Al Gore? No ☺
- Leonard Kleinrock who started Queuing theory providing the first theory of packet switching?
- Vint Cerf and Robert Kahn who defined the "Internet Protocol" (IP) and participated in the development of TCP?
- Tim Berners-Lee who developed HTTP to support a global hyper-text system he called the World Wide Web?

Computer Comms & Packet Switching



ARPA: 1957, in response to Sputnik

Paul Baran

- Early 1960s: New approaches for survivable comms systems; "hot potato routing" and decentralized architecture, 1964 paper

Donald Davies, early 1960s

- Coins the term "packet"

Len Kleinrock (MIT thesis): "Information flow in large communication nets", 1961

J. Licklider & W. Clark (MIT), On-line Man Computer Communication

L. Roberts (MIT), first ARPANET plan for time-sharing remote computers, SOSP '67 paper

Project Funded → ARPANET

BBN team that implemented
the interface message processor

ARPANet

- 1967: Connect computers at key research sites across the US using pt-to-pt telephone lines
- Interface Message Processors (IMP) ARPA contract to BBN
- Senator Ted Kennedy sent a telegram to BBN to congratulate them on winning contract to develop an "interfaith message processor".

ARPANET Topology in 1969

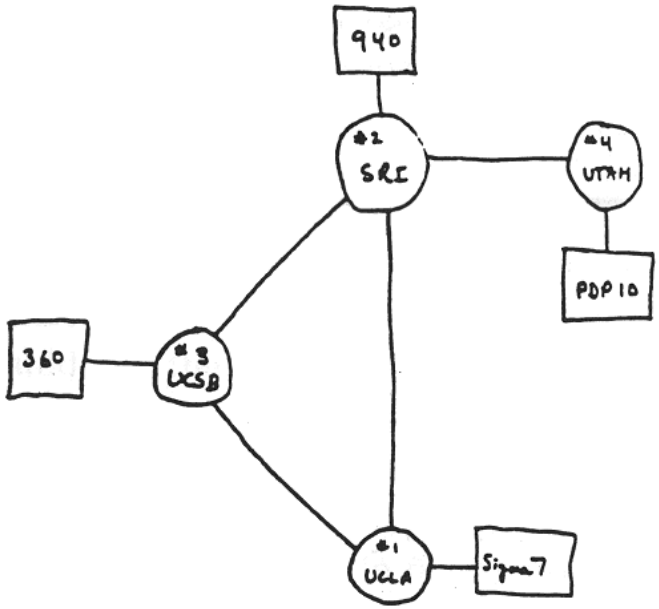


FIGURE 6.2 Drawing of 4 Node Network (Courtesy of Alex McKenzie)

First inter-site demo, 1969.
First crash very soon after!

1969: First Connections

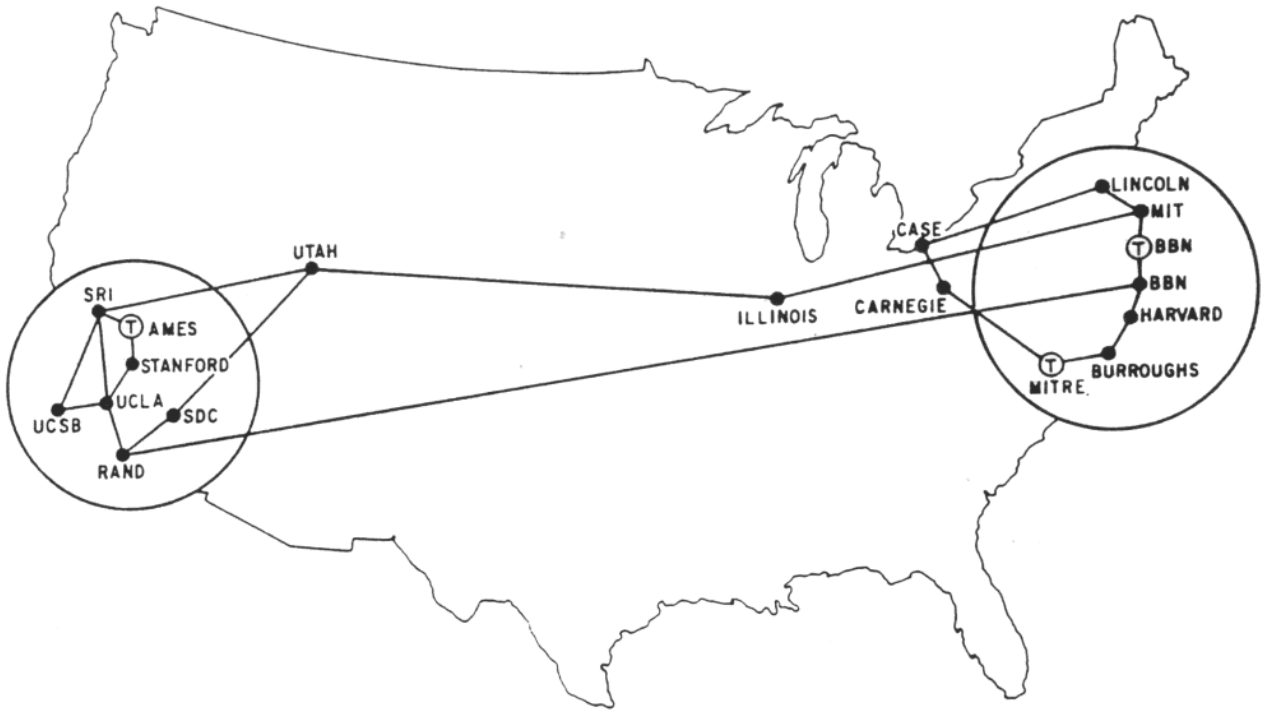
- 4/7/1969 – First RFC ("Host Software" by Steve Crocker) basis for the Network Control Protocol(NCP)
- 9/2/1969 – Leonard Kleinrock's computer at UCLA becomes first node on the ARPANET
- 10/29/1969 – First packets sent; Charlie Kline attempts use of remote login from UCLA to SRI; system crashes as "G" is entered

1967-1971: So what do we do with it?

- 1967-1972 – Vint Cerf, graduate student in Kleinrock's lab, works on application level protocols for the ARPANET (file transfer and Telnet protocols)
- 1971 - Ray Tomlinson of BBN writes email application; derived from two existing: an intra-machine email program (SENDMSG) and an experimental file transfer program (CPYNET)

1971-1973: Networks Growing

- 1970 - First 2 cross-country link, UCLA-BBN and MIT-Utah, installed by AT&T at 56kbps



MAP 4 September 1971

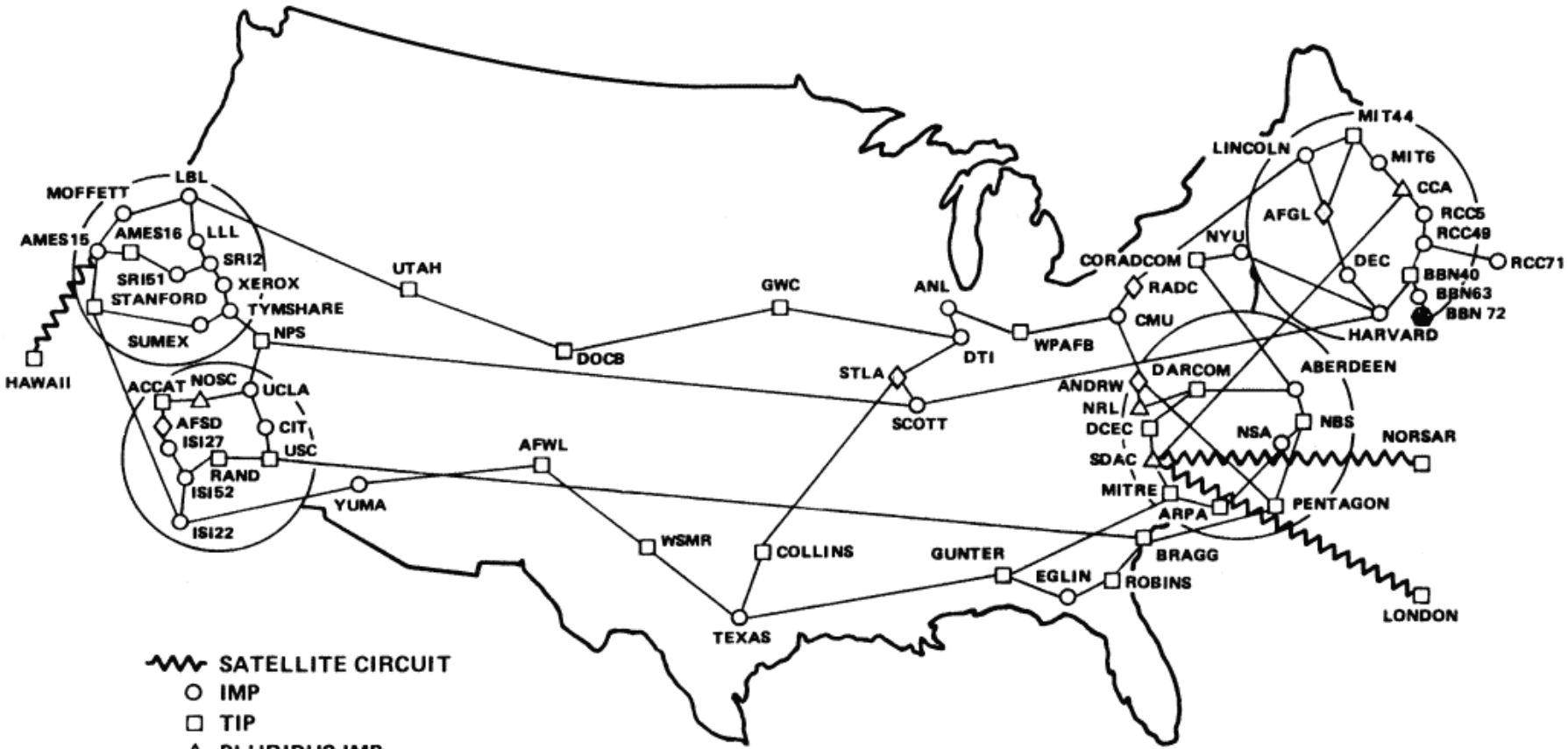
1971-1973: Networks Growing

- 1970 - First 2 cross-country link, UCLA-BBN and MIT-Utah, installed by AT&T at 56kbps
- Other networks: ALOHAnet (microwave network in Hawaii), Telenet (commercial, BBN), Transpac (France)
- 1973 – Ethernet was designed in 1973 by Bob Metcalfe at Xerox Palo Alto Research Center (PARC)
- How do we connect these networks together?

1972-1978: IP/TCP

- 1972-1974 – Robert Kahn and Vint Cerf develop protocols to connect networks without any knowledge of the topology or specific characteristics of the underlying nets
- 1974 – First full draft of TCP produced
- Nov 1977 - First three-network TCP/IP based interconnection demonstrated linking SATNET, PRNET and ARPANET
  - »
- 1978 – TCP split into TCP and IP
  - The IP hourglass

ARPANET GEOGRAPHIC MAP, OCTOBER 1980

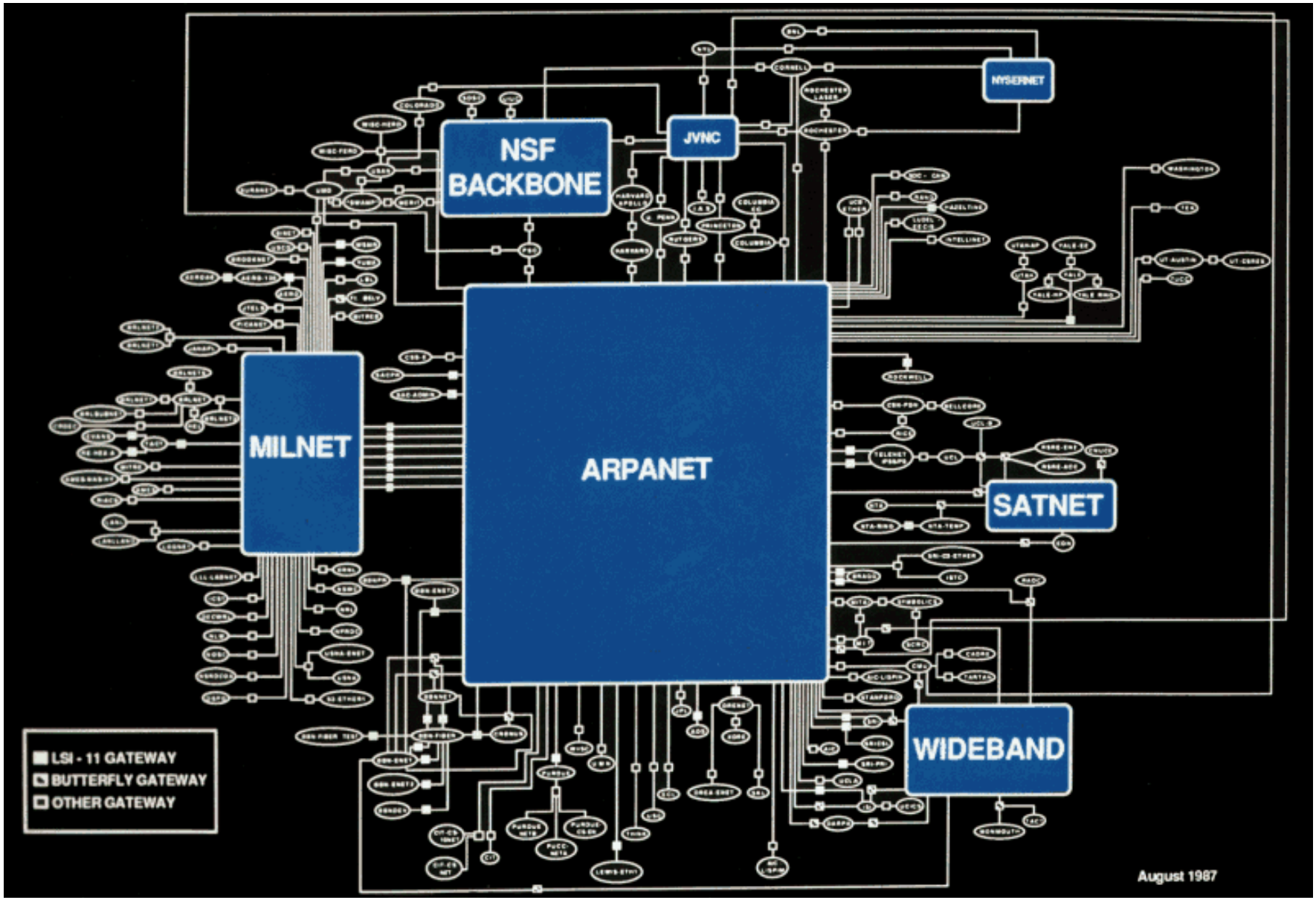


(NOTE: THIS MAP DOES NOT SHOW ARPA'S EXPERIMENTAL SATELLITE CONNECTIONS)
NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

1981 –1988: Growing, Excitement & Pain

- 1981 – Term "Internet" coined to mean collection of interconnected networks
- 1983 – ARPANET split into ARPANET and MILNET; MILNET to carry defense related traffic
- 1984 – Cisco Systems founded
- 1984 – Domain Name System introduced (DNS)
- 1986 - Congestion collapse episodes, Van Jacobson's solutions
- 1988 - Nodes on Internet began to double every year
- Nov 1988 – Internet worm affecting about 10% of the 60000 computers on the Internet (Robert Morris, Cornell)
- Decentralized administration

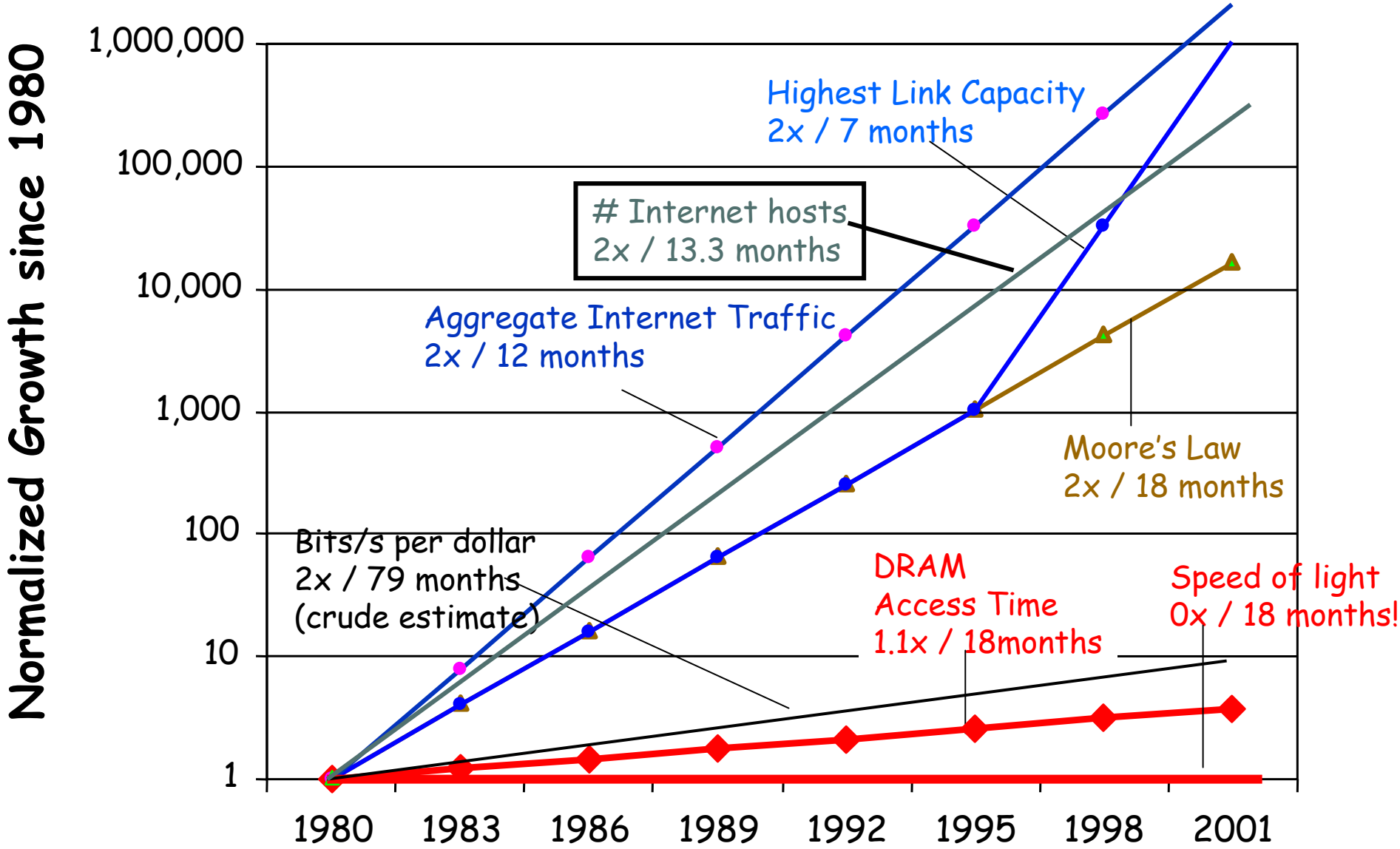
Some Decentralized Administration (1987)



1990-1993: WWW & Commercialization

- 1990 – ARPANET ceases to exist
- 1990 – Tim Berners-Lee invents the Web and develops HTML and HTTP
- 1990 – First ISP world.std.com
- 1991 – NSFNET lifted restrictions on use of NSFNET for commercial purposes
- 1993 – InterNIC created by NSF to provide Internet services; Private companies transition into roles (AT&T – directory and database services; Network Solutions – registration services; CERFnet – information services)

d(technology)/dt for networks



Thanks to Nick Mckeown @ Stanford for some of these data points

Vint Cerf: Open Challenges

- Vint Cerf: "My primary disappointment has been the slow pace of high speed access for residential customers … The second area of disappointment is the slow uptake of version 6 of the Internet protocol (IPv6). Perhaps the third area is the continuing difficulty caused by viruses, worms and distributed denial of service attacks."

How to make the Internet better???!

- Addressing current problems
  - Security
  - Privacy
  - Self-diagnosis & self-healing networks
  - Cheap connectivity for poor area and third world countries
  - Wireless mesh networks
  - sensors
  - Mobility
- New cool apps
  - What is after IPTV, VoIP, BitTorrent, …

Interesting uses of the Internet

Announcement

- Next two lectures will be by Prof. Kaashoek
- PS1 will be given in recitation tomorrow