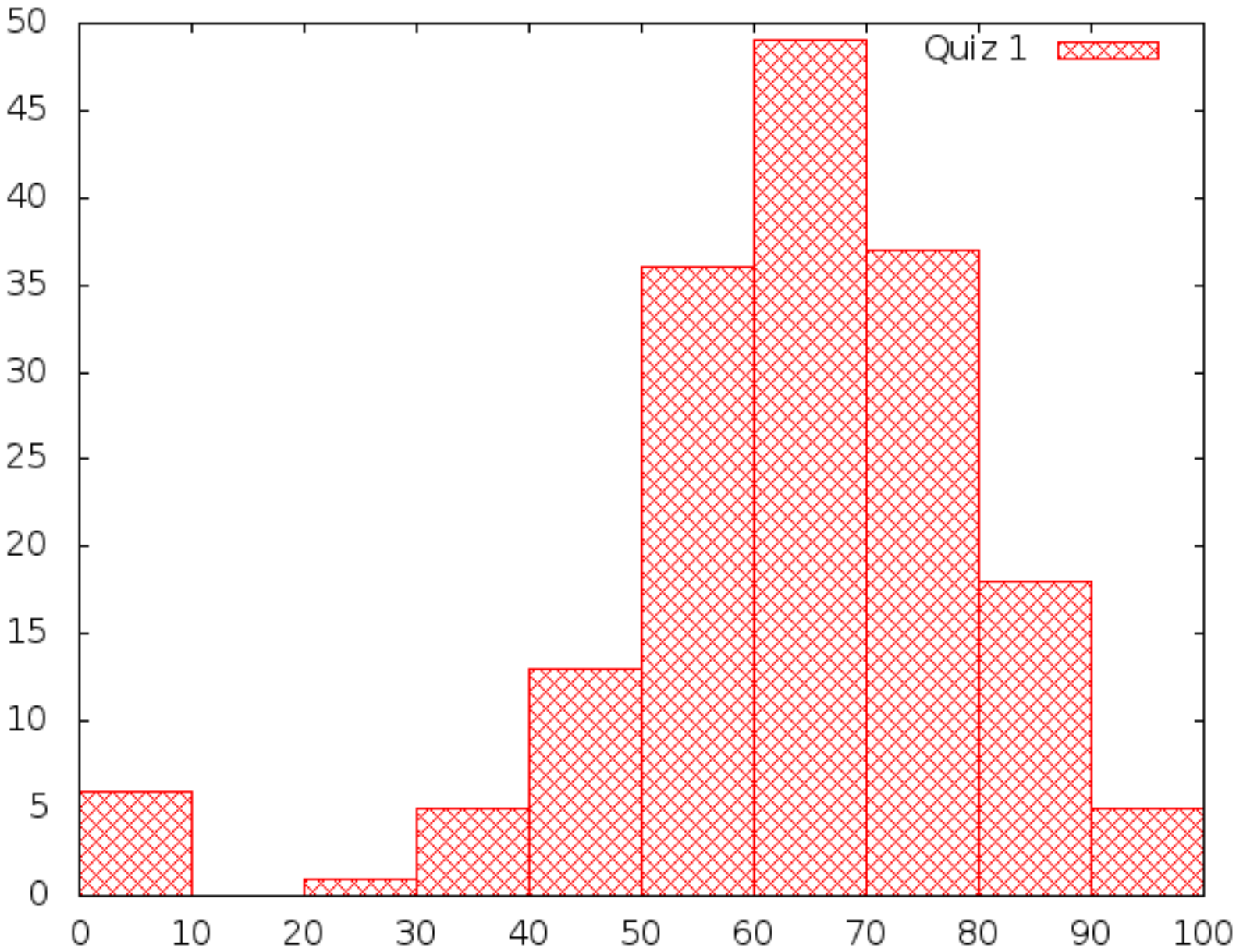
Quiz 1
50
45
40
35
30
25
20
15
10
5
0
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20
30
40
50
60
70
80
90
100

L10: Network Systems

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6.033 Spring 2011

http://web.mit.edu/6.033

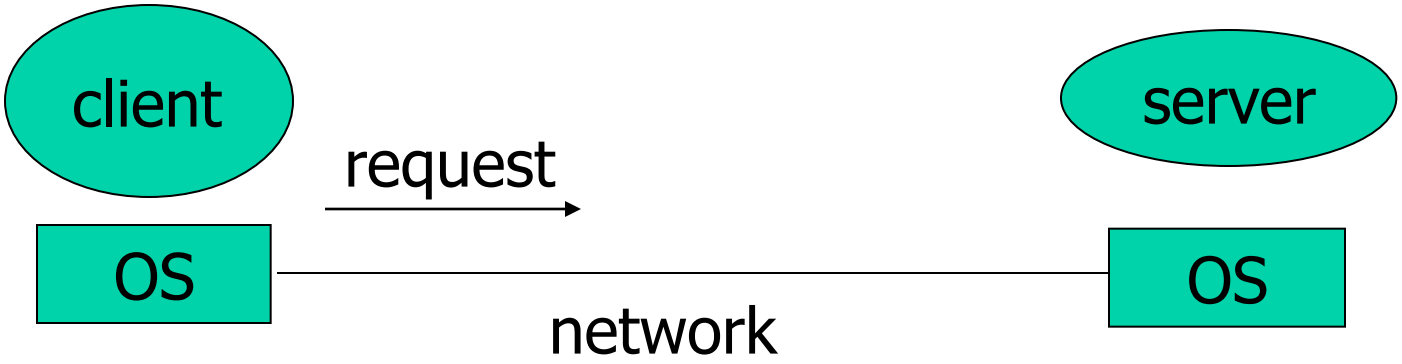
Some slides are from lectures by Nick Mckeown, Ion Stoica, Dina Katabi, Hari Balakrishnan, Sam Madden, and Robert Morris

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

What have you seen so far?

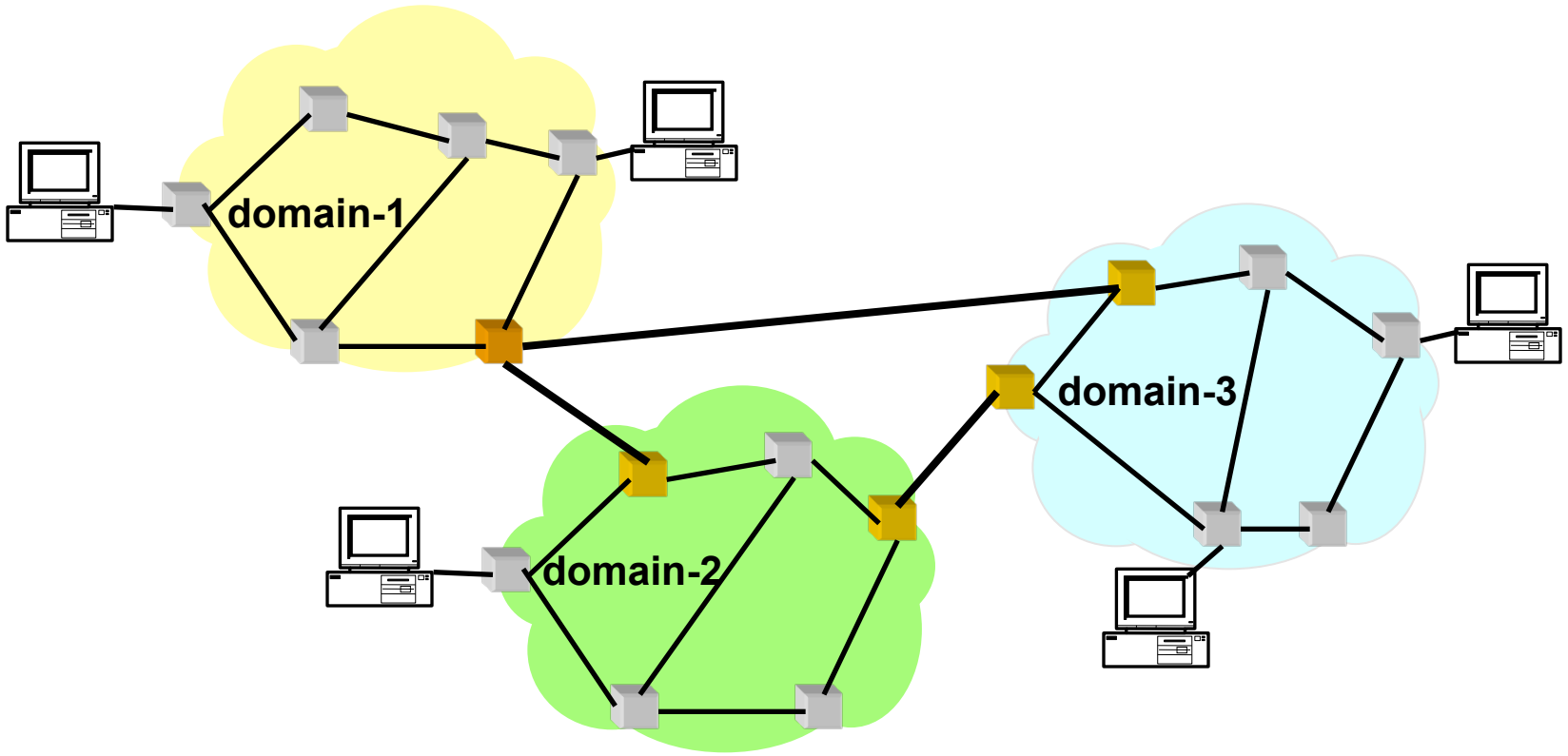
Systems	Complexity Modularity Dtechnology/dt	Hierarchy Therac-25
Naming systems	Gluing systems	File system name space/DNS
Client/service design	Enforced modularity	X windows
Operating systems	Client/service with in a computer	Eraser and Unix
Performance	Coping with bottlenecks	MapReduce

Client/service using network



- Sharing irrespective of geography
- Strong modularity through geographic separation

Network is a system too!

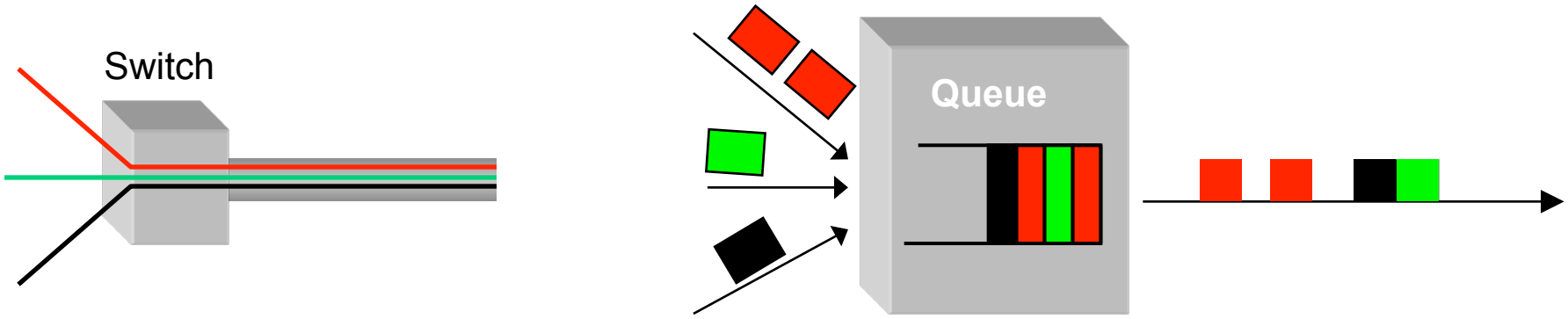


- Network consists of many networks, many links, many switches
- Internet is a case study of successful network system

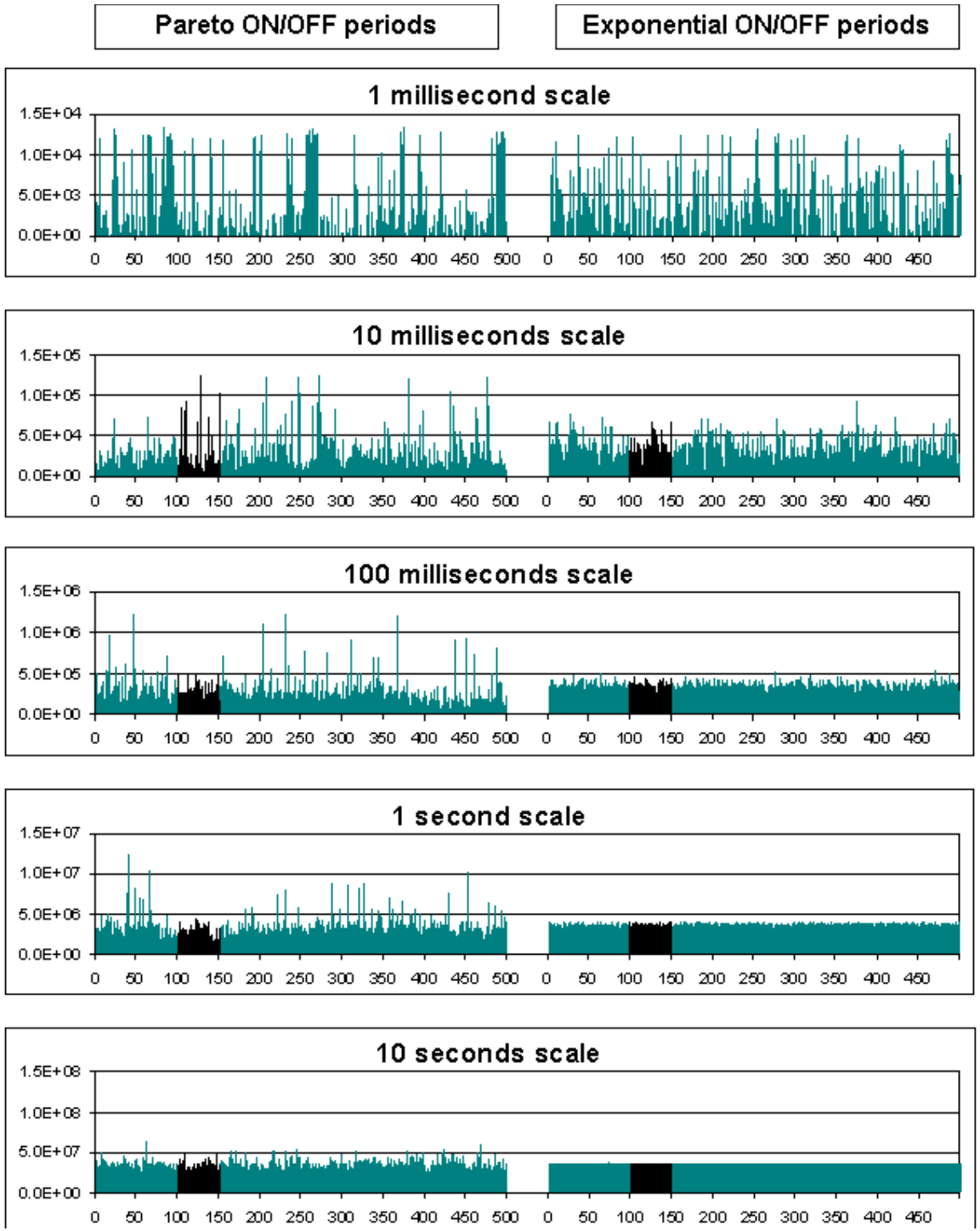
Today's topic: challenges and approach

- Economical:
  - Universality
  - Topology, Sharing, Utilization
- Organizational
  - Routing, Addressing, Packets, Delay
  - Best-effort contract
- Physical
  - Errors, speed of light, wide-range of parameters
- Approach: protocols and layering

Asynchronous Multiplexing/ Demultiplexing

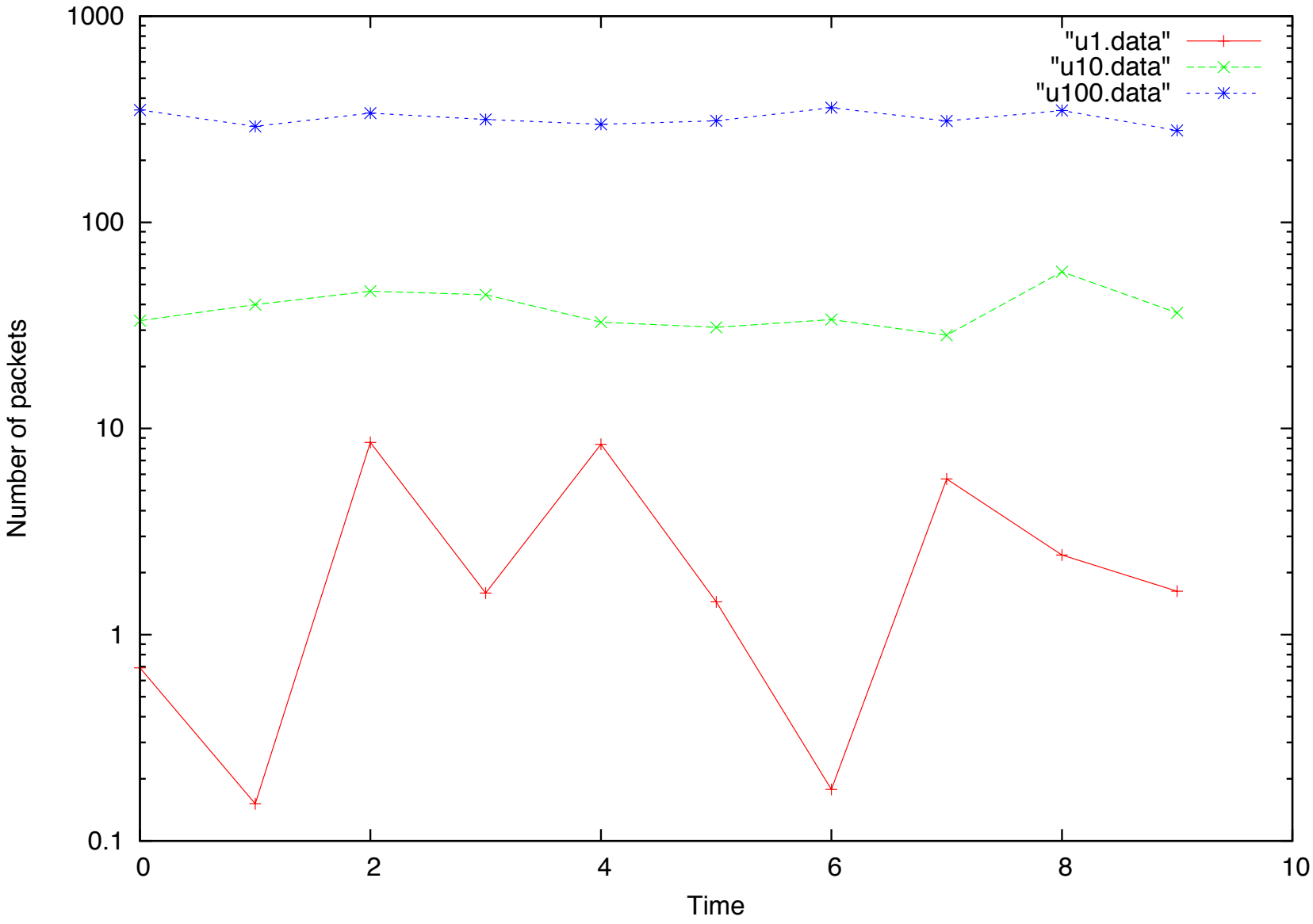


- Multiplex using a queue
  - Switch need memory/buffer
- Demultiplex using information in packet header
  - Header has destination
  - Switch has a forwarding table that contains information about which link to use to reach a destination



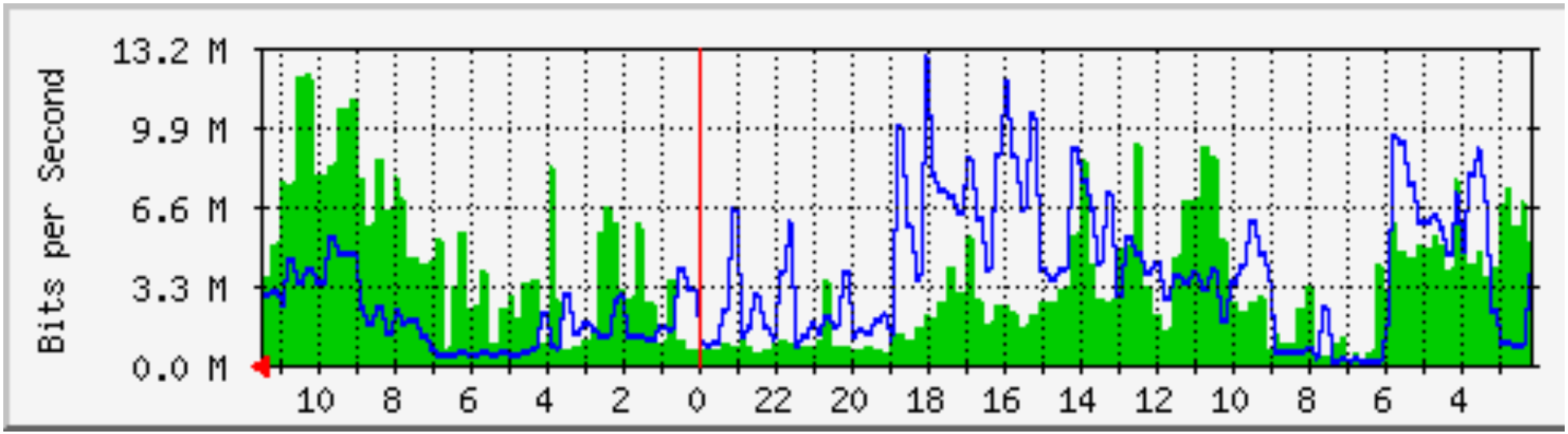
Queue length

Statistical multiplexing



Aggregate Internet Traffic Smooths

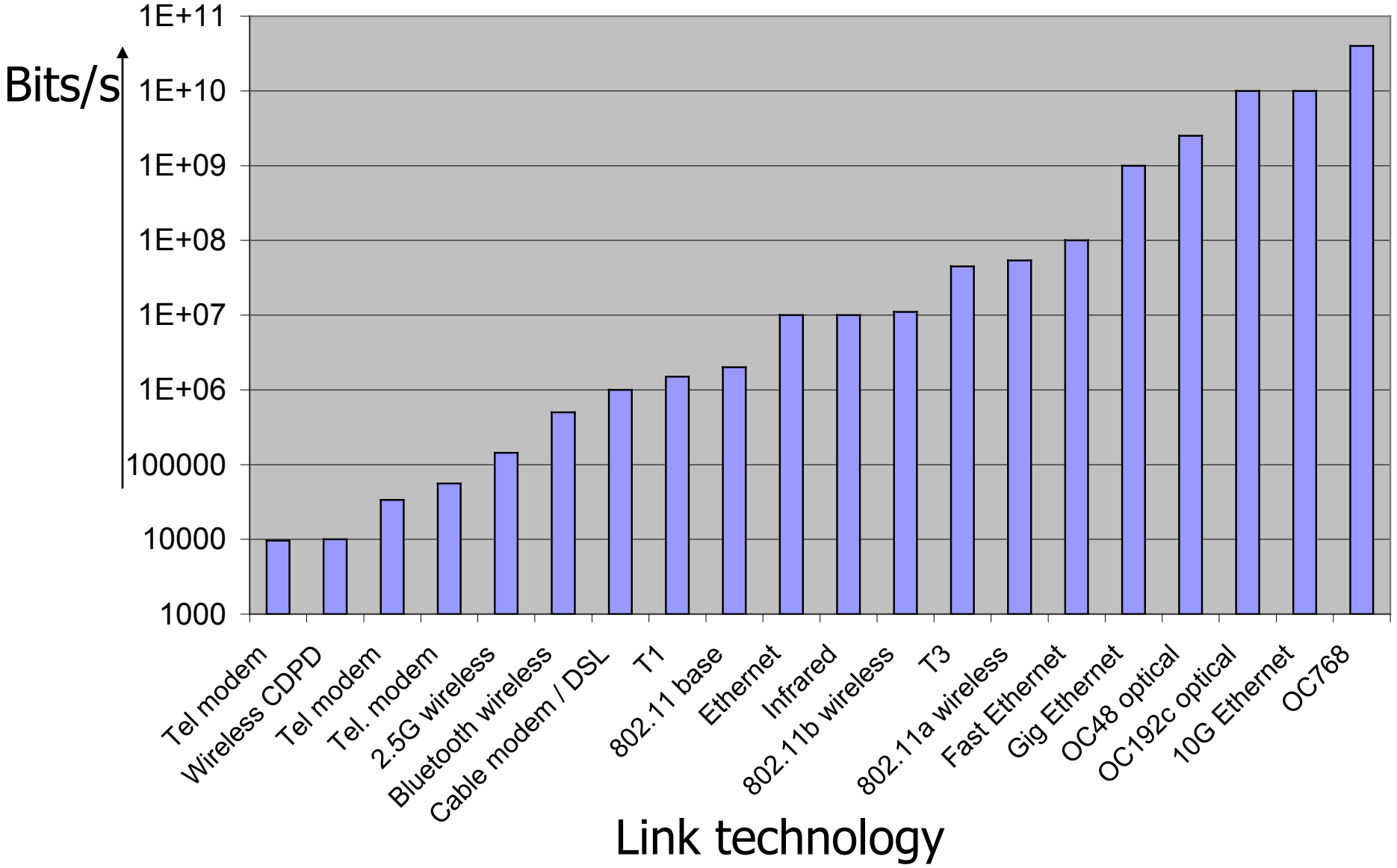
5-min average traffic rate at an MIT-CSAIL router



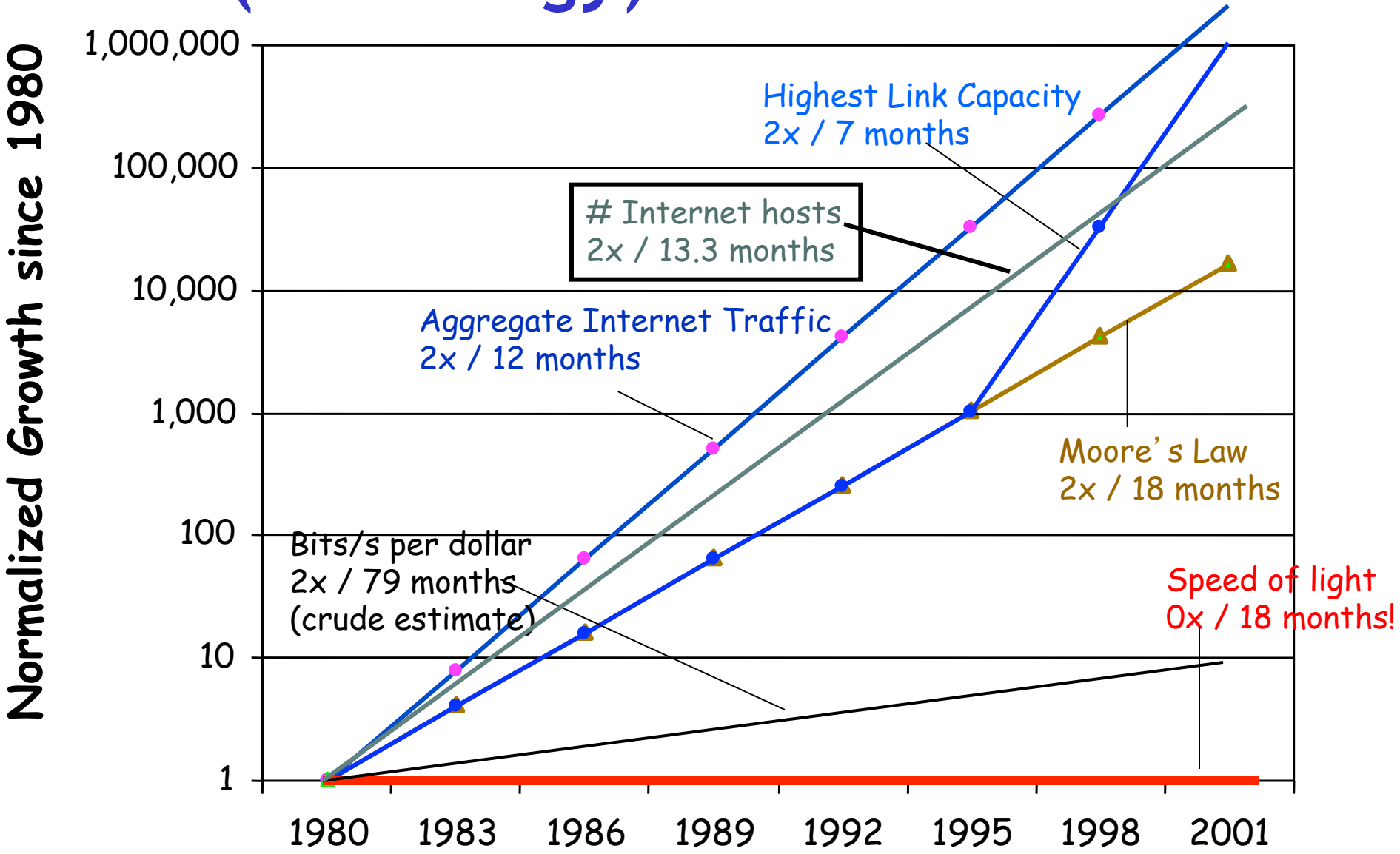
Max In:12.2Mb/s Avg. In: 2.5Mb/s

Max Out: 12.8Mb/s Avg. Out: 3.4 Mb/s

Networks are heterogeneous



d(technology)/dt for networks



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

Internet: Best Effort

No Guarantees:

- Variable Delay (jitter)
- Variable rate
- Packet loss
- Duplicates
- Reordering