Some Economic Issues for Information Networks

Jeff MacKie-Mason

Dept. of Economics and Institute of Public Policy Studies
University of Michigan

Slides available:

`http://www.ipps.lsa.umich.edu/ipps/papers/info-nets/msri/msri.html`

Further resources:

`http://www.ipps.lsa.umich.edu/telecom-info.html`
(telecom broadly)

`http://gopher.econ.lsa.umich.edu/EconInternet.html`
(Internet economics)

Outline

- Congestion
- Commerce
- Market Structure

Congestion

- What is congestion?
- Is there congestion?
- Why?
- Why does it matter?
- How to allocate congestible network resources?
- How to do pricing

What is congestion?

- A user's benefit decreases as total usage increases
- Thus, my usage increase imposes costs on other users
- Congestion is matter of degree:

efficient use of a resource usually means non-zero congestion

Is there congestion?

- content archives (e.g., Archie, Simtel, UM's Mac & Dos archives)
- multimedia (Mosaic, MBONE, CU-SeeMe)
  - 1992 Finnish videoconference broadcast
  - undergrad chat
- advertising on Usenet
- 1986 and 1987 interactive traffic slowdowns

Why?

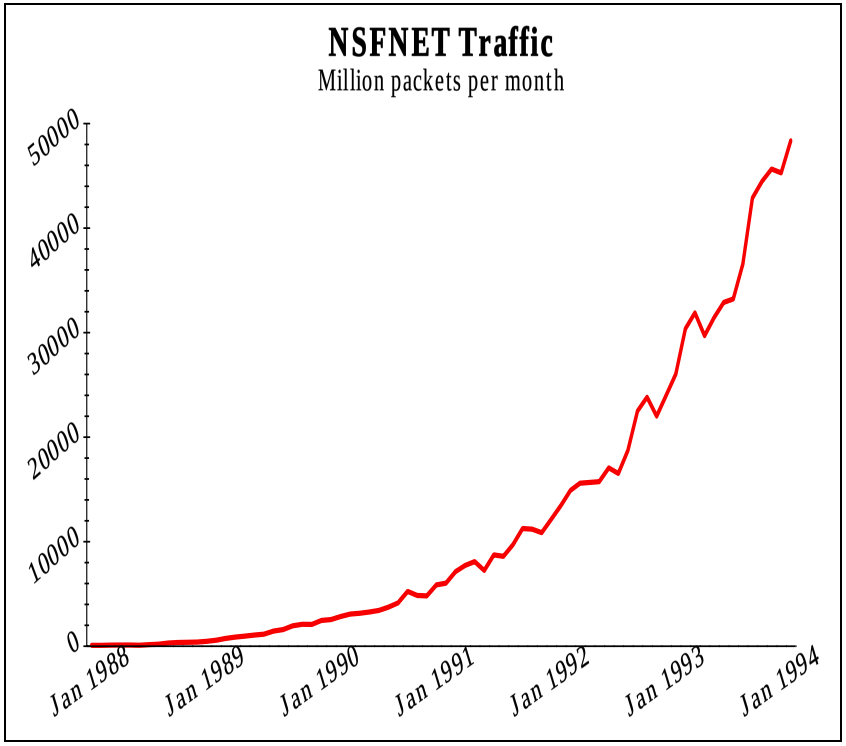
- How big is the Internet?
- Traffic growth on NSFNET
- Growth in Hypermedia --(WWW)
- Problem of the Commons
- Packet technologies

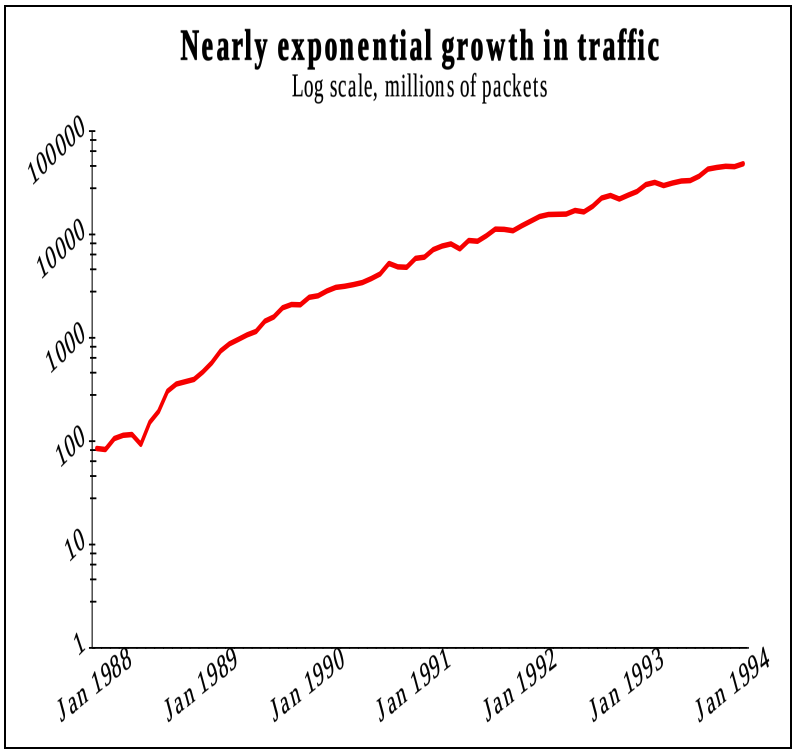
How big is the Internet?

	1985	July 1993	July 1994
Networks	200	13,767	25,210
Hosts	1,961	1,776,000	3,212,000
Countries		57	75

Traffic growth on NSFNET

- 100 billion packets per month (October 94)
- 21 trillion bytes
- Increase by **factor of 860** in under 7 years (8.8% / month)
- **6% per month** over last 3 years = doubling each year





Growth in Hypermedia -- WWW

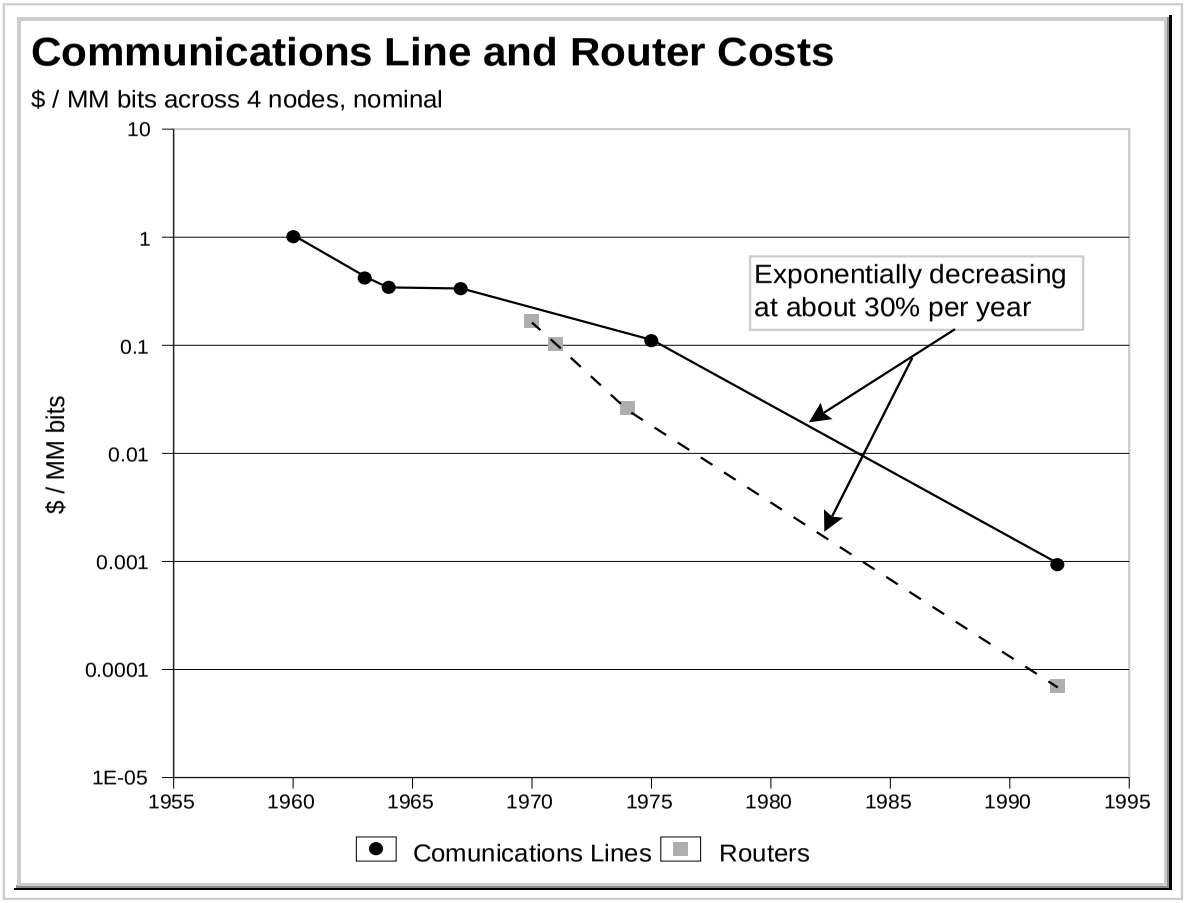
- 0.002% of traffic in Jan '93
- 8.6% in Sept '94
- 10.2% in Oct '94

- **41% / month compound growth rate!**

Problem of the Commons

- on a highway, single user can add 1 car
- on Internet, single user can add
  - 2-3 Kbps (email)
  - 1-10 Mbps (real-time video)
  - **factor of 5000!**
- yet all users pay the same usage charge: $0

Packet technologies



- **benefits**
  - **statistical multiplexing: efficient use of lines vs. switches**
- **costs**
  - **no resource reservation**
  - **network sees packets, not sessions**
- **ATM (virtual circuits) compromises**

Why does it matter?

- heterogeneous preferences
  - different users -- different values
  - first in line will often value speed less than those in back
- heterogeneous services (multiple QoS)
  - different services require different service guarantees
  - e.g., bandwidth, max delay, delay variation, holding time, packet loss
  - how to prevent MBONE from eating all available bandwidth?
  - how much resource for telesurgery vs. undergrad video MUD?

How to allocate congestible network resources?

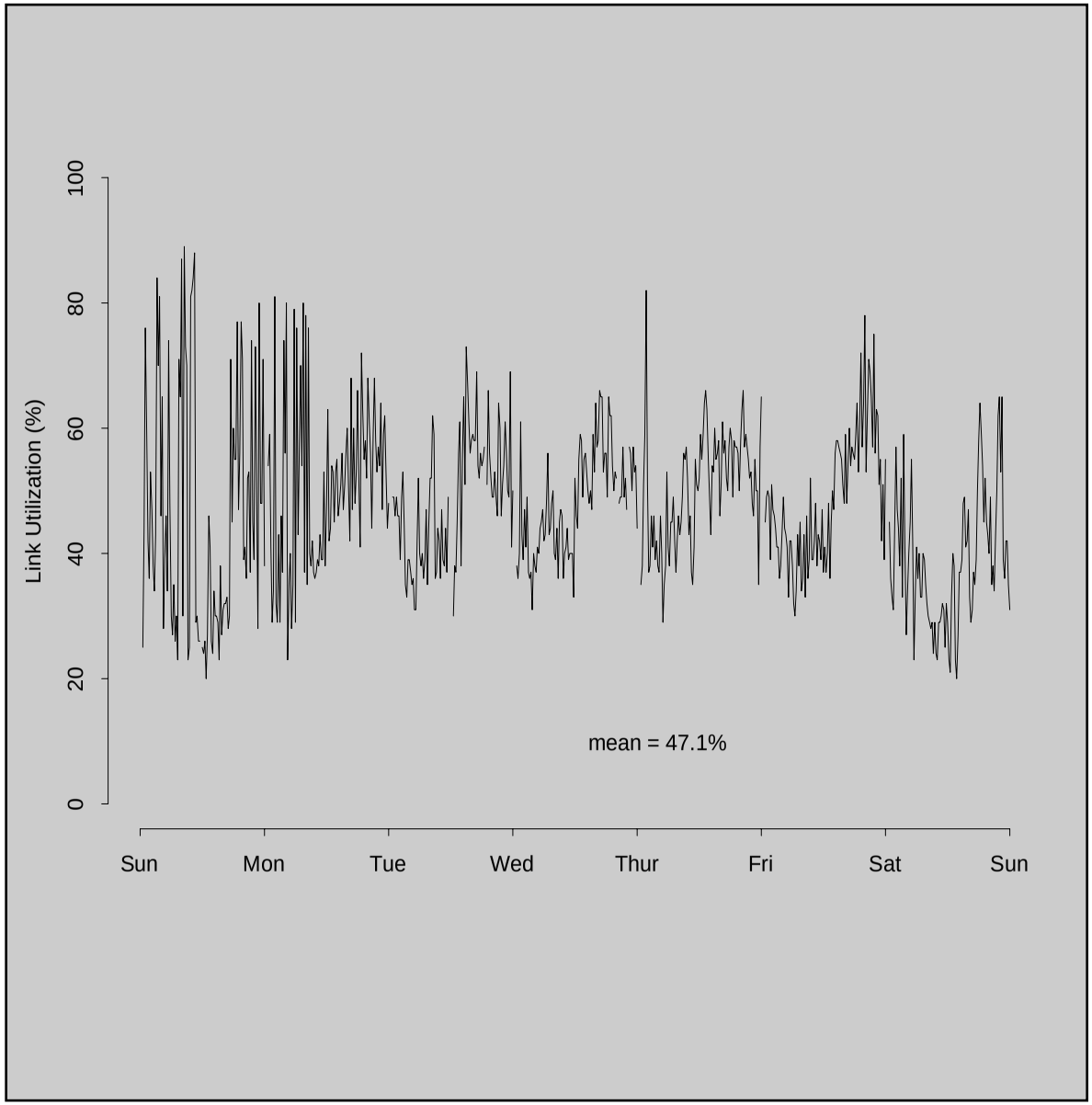
- altruism
  - nice guys finish last
- rationing
  - priority based routing
  - but who decides the priorities?
- throw money at it
  - who? how much? why not AIDS research?
  - who pays for GE's corporate communications?
- pricing
  - allocate service qualities to those who value them the most

How to do pricing

- **Tasks for pricing**
  - truthful reporting of type-of-service/precedence
  - capacity expansion
  - cost recovery

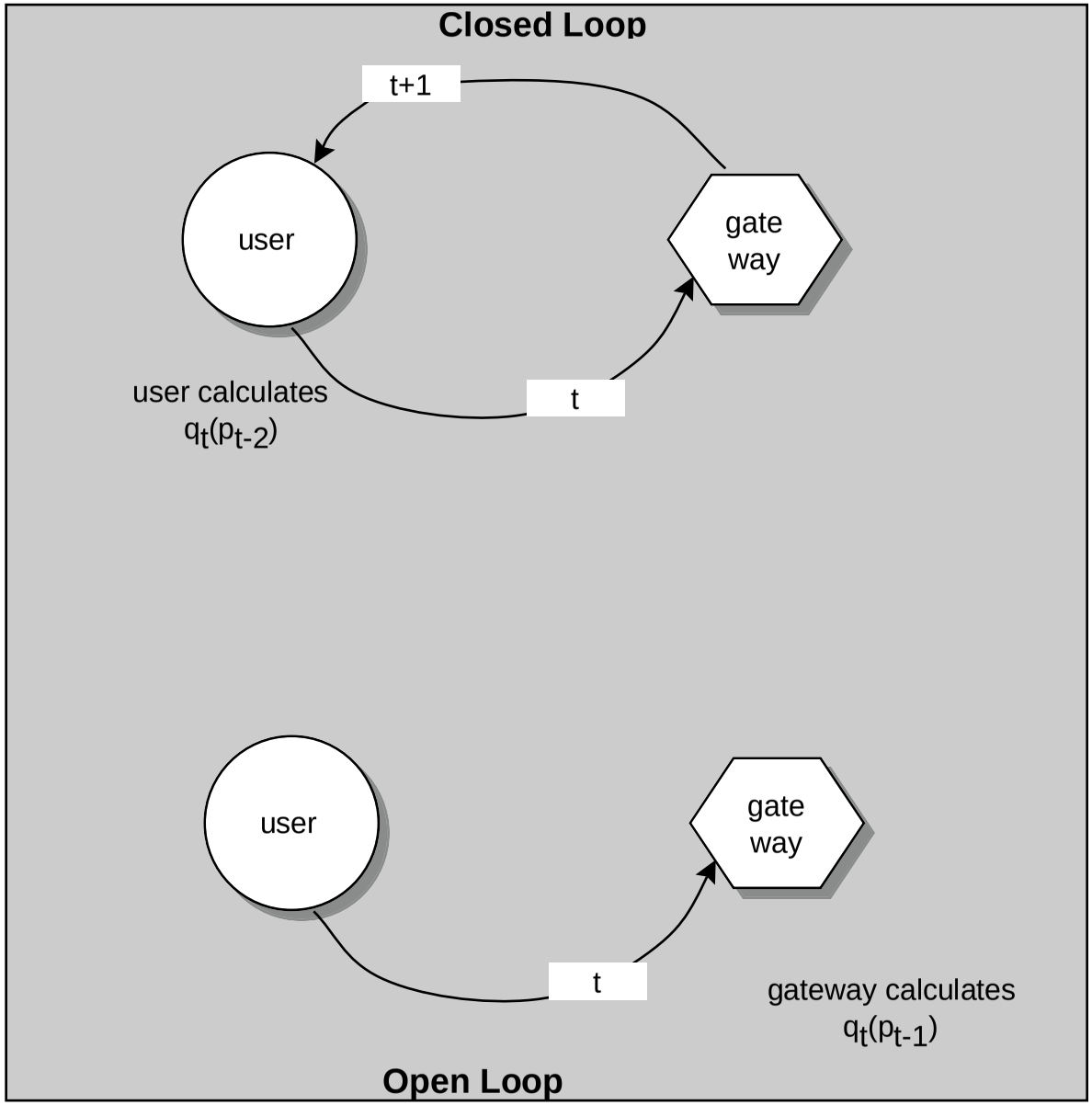
  - Usage-based pricing helps solve these problems

How to do pricing Cont d



- **Pricing -- Posted or time-of-day**
  - **shifting peaks -- smart devices**
  - **high frequency variation --> need high frequency prices**

How to do pricing Cont d



- **Responsive Pricing**
  - **closed loop: delay*bandwidth problems**
  - **open loop: real-time "smart markets"**

Currency

- What's wrong with current systems
  - assume parties will be in each other's presence
  - or, sufficient delay to check for fraud

⇨ high transactions costs (e.g., Compuserve model)

Desirable characteristics for currency

- security
  - copying and double-spending
  - nonrefutability
- anonymity
  - can't monitor spending patterns
  - can't identify source of income
- scalability
  - central server problem
  - checking double spending problem
- acceptability

Desirable characteristics for currency cont.

- off-line payment
  - buyer-seller transaction without concurrent link to bank host
- transferability
- divisibility
- hardware independence
  - doesn't depend on special devices
- low transactions cost

What can be done about it?

- Types of electronic currency

	Cash	Credit Cards	Checks	Certified Checks
Security				
Anonymity	+	-/?	-	+
Scalability				
Acceptability	+	-/?	-	-/?
Off-line Operation	+	-	+	+
Transferability	+	-	-	-
Divisibility	+	+	+	-
Hardware Independence	+	+	+	+
Low Cost				

What can be done about it? Cont d

- Examples
  - Digicash (money orders)
  - NetBill (credit cards)
  - First Virtual (credit card for shareware)
  - NetCash (semi-anonymous cash)
  - Cybercash (credit card facilitation)

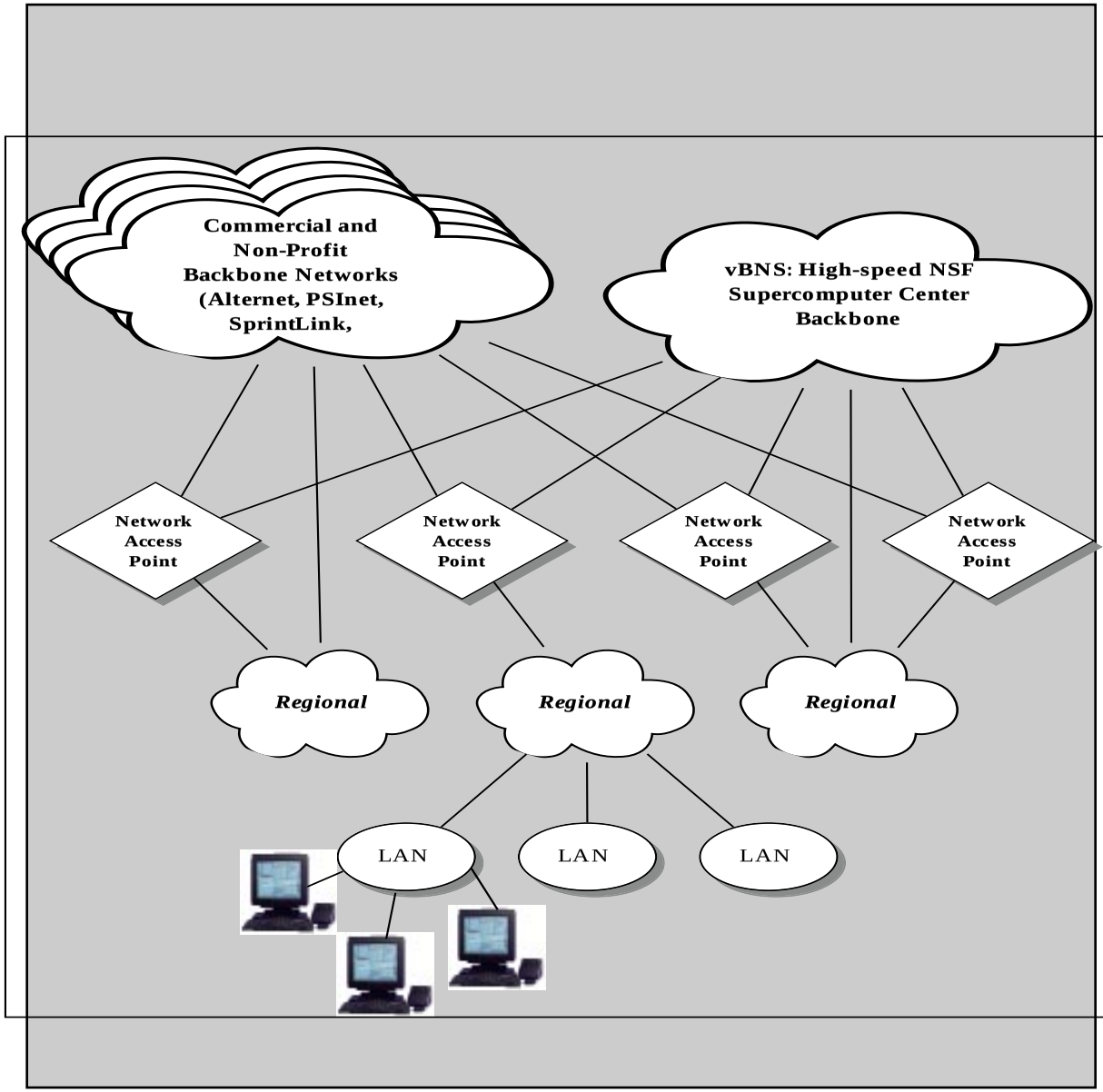
Implications for electronic publishing?

- **Needs:** low bandwidth, delayable distribution
- for this, distribution costs about zero
  - the costs are driven by high bandwidth, low-delay applications
- accounting and charging protocols for content are emerging
  - ex: UM Digital Library developing protocols for price negotiations, accounting and charging for publishing, searching and retrieval

Market structure

- How is the Internet changing?
- Implications for Market Structure
- Competitive drive towards usage-sensitive pricing

How is the Internet changing?



- NSF phasing out NSFNET backbone
- Network Service Providers: user funded
- NSF will fund
  - Network Access Points
  - Routing Arbiter
  - vBNS : supercomputer net

Implications for Market Structure

- Fundamental Problem:
  - High fixed costs
  - Low marginal costs
- Reseller arbitrage
  - High connection fees with volume discounts, low usage prices
  - Resellers bundle small users, buy at high volume rates -- with no fixed costs to recover
  - Original MCI vs. AT&T
- How can components compete?
  - If ISPs interconnect, no one has the incentive to provide a the backbone (free riding)
  - Prediction: zero settlements CIX cannot survive

Competitive drive towards usage-sensitive pricing

- If setup costs low, will see multiplicity of providers with different service configurations
  - low cost, high congestion
  - high cost, low congestion
- Efficient (usage-sensitive) prices accomplish two objectives:
  - maximize total benefits of current users
  - correctly guide investment in growth
- If no natural monopoly elements, competitive market will yield optimal allocation/investment