Economic FAQs about t Internet

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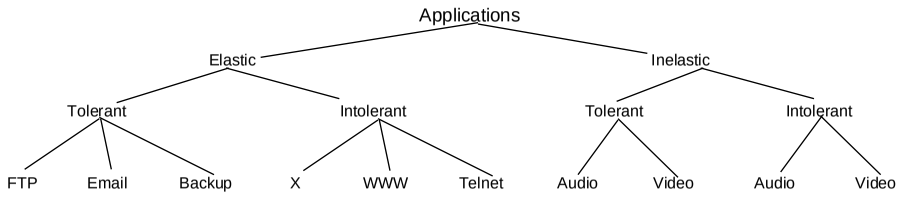
Based in part on a paper published in the Journal of Ecc Perspectives, Summer 1994

This and other materials available at:
http://gopher.econ.lsa.umich.edu (esp. Inte
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Overview

- Vision
- Internet structure and growth
- Information delivery
- Information content
- Policy issues

Vision: Open Integra Services Network



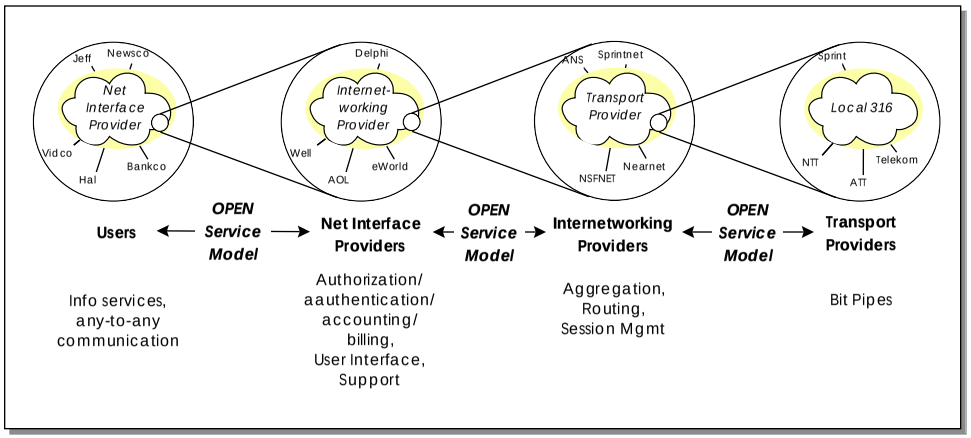
Open, Integrated Services:

- "Information Outlet"
- "Open Data Network" (NAS)
- "Open Platform" (EFF)

What infrastructure can support this?

- Technological
- Economic

Open Architecture



- What economic problems face an Integrated Se Open Architecture network?
- What economic ideas can help realize the vis

What do we learn from Internet?

- Integrated services model
- Open architecture
- Phenomenal growth
- Paradigm shift in technology

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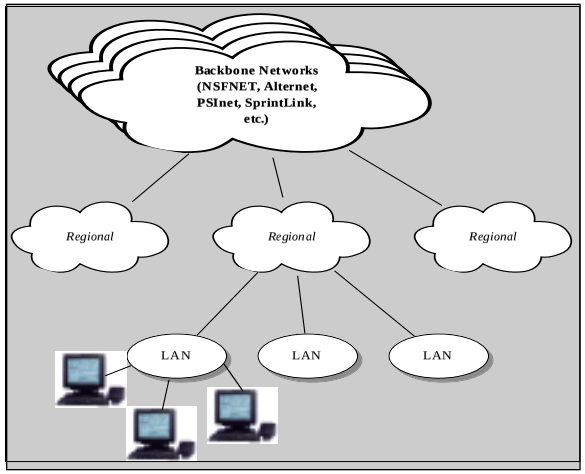
What do people do on Internet?

- Traffic (by bytes, Sept 94)
  - 32% file transfer
  - 13% information discovery (gopher/WWW)
  - 11% Usenet news
  - 10% overhead (IP,DNS)
  - 6% email
  - 5% remote login

Who runs the Interne

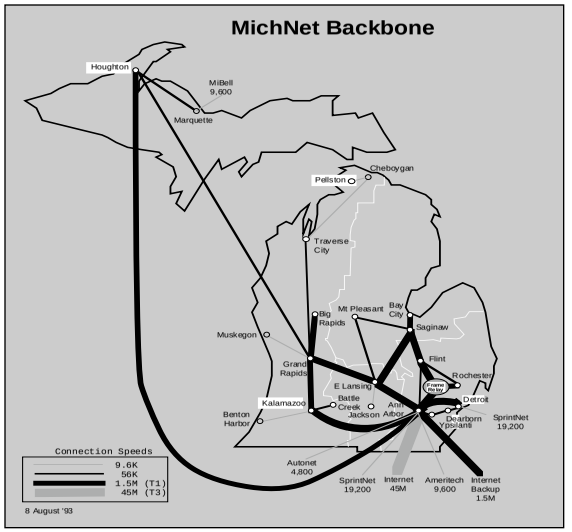
- Loose confederation
- Some key organizations in US
  - National Science Foundation
  - Internet Society (gopher.isoc.org)
  - Internet Engineering Task Force
  - CIX (Commercial Internet Exchange)

What is the structure c Internet?



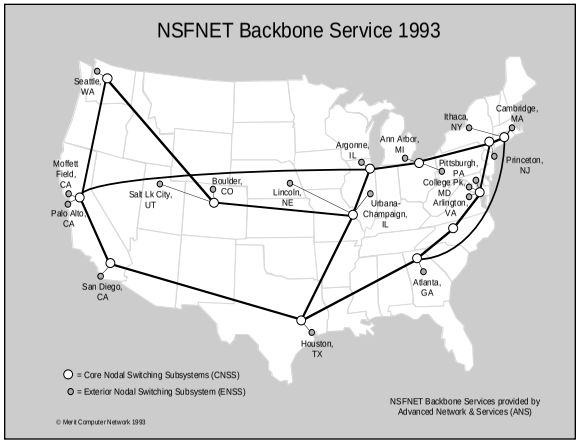
- LANS
- regionals
- backbone

What is a regional netw



- MichNet, BARRNET, THEnet
- financing
  - state agencies
  - user fees
  - NSF subsidies
- User cost:
  - $20K/yr
  - $10K connect

What are backbones?



- NSFNET
- Alternet, PSInet, SprintLink

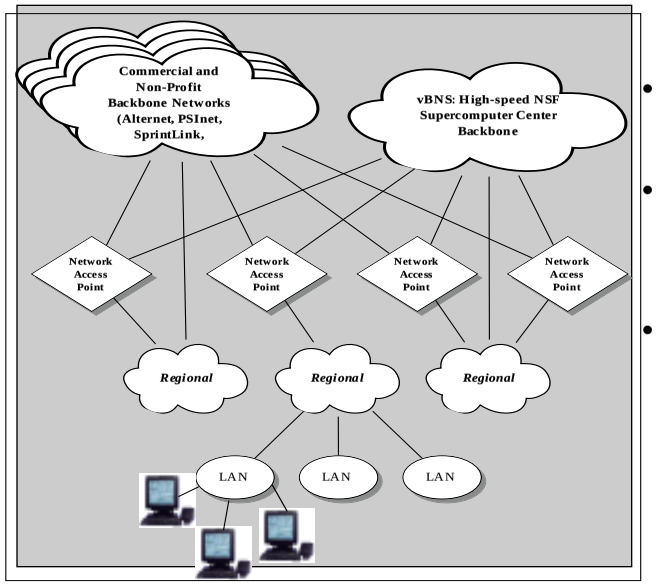
Why are there 4 backbc

- NSF's Acceptable Use Policy
- CIX, MAE-East, etc.
  - Multilateral and bilateral interconnection
  - No settlements

How much did NSFNET co

- NSF paid $11.5 per year million to Merit/ANS
  - 80% was lease payment for lines + routers
  - 7% for NOC (network operations center)
- NSF grants $7 million subsidies to regionals
- maybe 10 million US users?
- implies NSF subsidy of $2 per user per year

How is this changing?



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

What are independent providers?

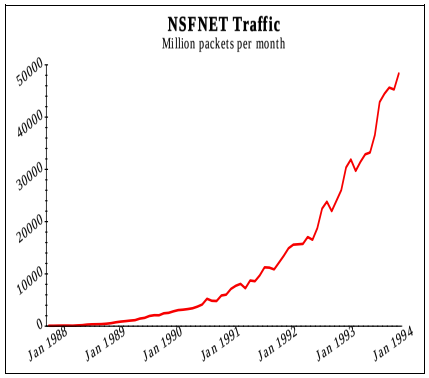
- America OnLine, Compuserve
  - Originally:
    - Proprietary content, limited connectivity
  - Soon:
    - Proprietary interface to non-proprietary Internet
    - Retaining proprietary content
- Direct connections and shell accounts
  - Bare bones interface, little standardization

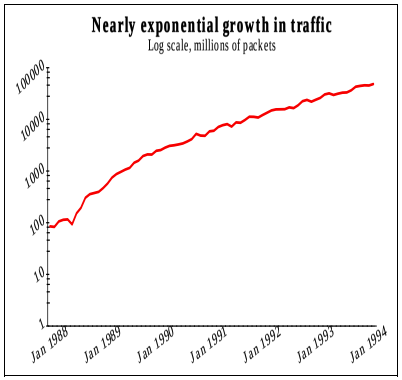
How big is the Inter

	1985	July 1993	July 199
Networks	200	13,767	25,210
Hosts	1,961	1,776,000	3,212,000
Countries		57	75

Traffic growth on NSFI

- 89 billion packets per month (packet ≈ 200 b (Sept 94)
- Increase by a factor of 860 in under 7 years month)
- 6% per month over last 3 years = doubling ea





Growth in Multimedi --(WWW)

- 0.002% of traffic in Jan ’93
- 8.6% in Sept ’94
- 61% / month compound growth rate!

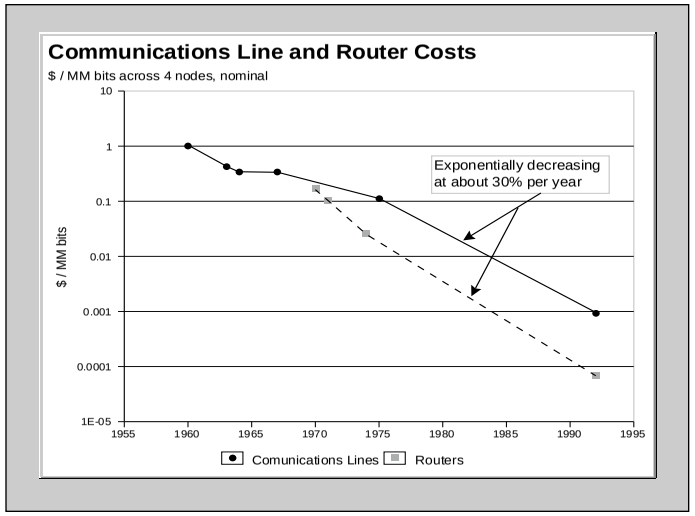
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Technology

- circuit switching: telephone
- packet switching
  - TCP/IP protocols
  - envelope analogy
  - packets share links: first-come, first-served
- connectionless vs. connection-oriented
- physically moves on telephone trunk lines an optic
  - much more efficient sharing of trunks than with circui

Why packet switching?



- switches are cheap relativ to lines
- packet switching use lines very efficiently
- all informati is digital

Where is network techn going?

- telephone, data, video are now all separate
- but may evolve to Integrated Services Networ
  - ATM (asynchronous transfer mode)
  - like packet switching but with connections
  - connections allow flexible resource sharing and account

How fast does it go

- mid 80s: 56 Kbps
- late 80s: 1.5 Mbs (T-1 line)
- early 90s: 45 Mbs (T-3 line)
  - 1,400 pages per second
  - 20 volume encyclopedia: coast to coast in 30 seconds
- 1994/95: 155 Mbs (ATM)

- 2800-fold speed increase since 1985

How is Internet access

- fixed bandwidth fee, no usage charge
  - $25/month dialup
  - $600/month leased 56Kbs line
  - $5,000/month for a large university
  - user support varies...
- most users face $0 marginal cost for packets

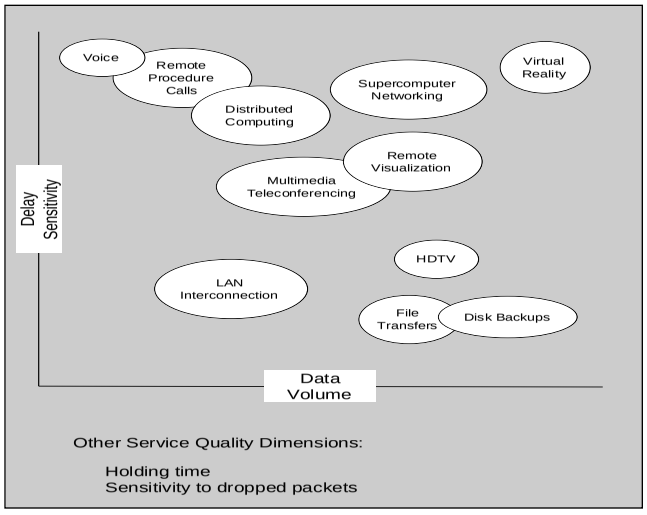
Congestion?

- congestion at content archives (e.g., Archie UM's Mac & Dos archives)
- multimedia (Mosaic, multicasts)
  - NCSA Mosaic Home: 1.3 million accesses per week!
  - 1992 Finnish videoconference broadcast
- advertising on Usenet
- transshipment

Problem of the Commo

- 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
- congestion externality

Many applications, vari qualities of service



- Resource sharing for near-term "bandwidth everywhere"
- But how to share with multiple dimensions?

How to allocate scar network resources?

- altruism
- rationing
  - priority based routing
  - but who decides the priorities?
- throw money at it
  - who? how much?
  - who pays for GE's corporate communications?
- pricing
  - allocate service qualities to those who value them the

Tasks for pricing

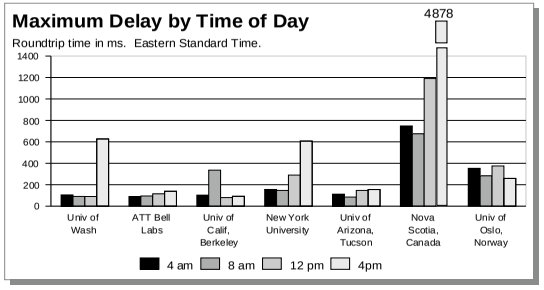
- truthful reporting of type-of-service/preced
- capacity expansion
- cost recovery

- Usage-based pricing helps solve these proble

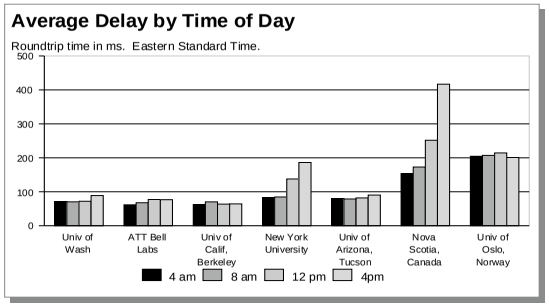
What should be price

- direct marginal cost is negligible
- connection cost is mostly fixed cost
- congestion cost: probably what you want to p
  - price has to vary by state of congestion
  - time of day or more frequently

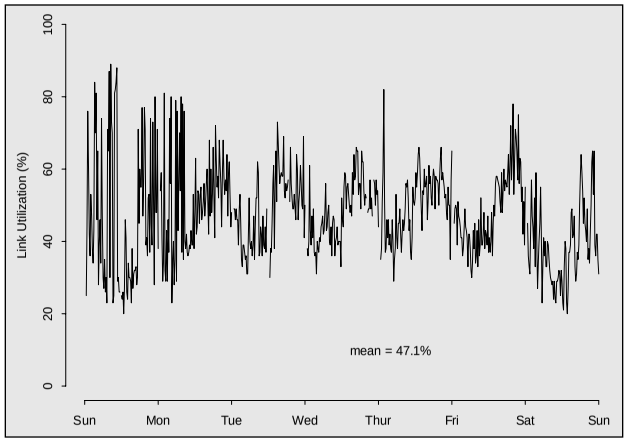
Delay by Time of Da



day



Weekly traffic patterns



- Very bursty
- Prices posted in advance wil be inefficient

Smart markets?

- How do they work?
  - bid for access: announce willingness-to-pa
  - high bids have priority
  - everyone charged the minimum price that c market
- Features:
  - budget controlled: never pay more than bi
  - price fluctuates with state of congestion
  - high-value users pay most of the cost of expansion
  - usually bids set by default

Markets for What?

- Network transport
  - wholesale, not retail?
- Information archives
  - ftp site
  - WWW server
  - digital library
- Digital agents
  - search services
  - interface agents

What about ability-tc

- The costs per user of most digital network r are very low
  - Recall: NSFNET subsidy only about $2/user/year
- With priority-pricing, most of the costs are high-value or high-intensity users
  - All the email can go through at $0, with modest or negl delays
- Ability-to-pay is an endemic problem in soci
  - much broader politics than just information networks
  - separation approach: redistribute income appropriately (info-stamps?) and then let users pay the social cost o

Experience with usage-pricing

- Chile
- New Zealand
- Australia

Other Delivery Probl

- Internet accounting
  - phone company method?
    - 1 minute "phone" call: 2,500 records
    - 10 minutes: 25,000 records
  - who pays, sender or receiver?
  - Approach: "digistamps"
- Internet cash
  - Many methods in development, trial
  - Varying approaches: cash, check, credit card, money ord
  - Issues
    - re-use fraud
    - anonymity
    - float
    - transactions cost

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Problems with informati

- Information goods
  - databases, photos, recordings, movies
  - software, books, journals, newspapers, etc.
- Don’t know what you are buying
- Public good problems
  - nonexcludable -- copying is (almost) free
  - nondiminishable -- no (direct) social cost to copying
- Public utility problems
  - high fixed costs

What are you buying‘

- subscription pricing: repeated interaction
- two-part tariffs: connect/subscription fee + fees?
- pricing various dimensions of product
  - immediacy
  - history
  - indexing and organization of data
  - format of data

Copying?

- how much protection is appropriate?
  - compare benefits from innovation to cost from monopoly
  - optimal patent literature
- can offset some copying by pricing/productio decisions
  - the lower the price, the less illicit copying
- what should optimal penalties/protection loo
  - private costs: copy protection costs
  - public costs: legal enforcement

Covering fixed cost

- price discrimination
  - yield management
  - policies of current on-line services
- make sure proposed accounting and billing sy can handle flexible pricing schemes
- how to make the information providers compet
  - open architecture
  - artificial shopping agents
  - mechanism design

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Public Policy Issue

- Competition with telephony, cable TV
  - Pricing models influence market structure
- Universal access?
  - what does it mean?
  - top-down or bottom-up subsidies?
- Industry structure

Industry Structure

- Regulation and the Service Model
  - Community or global networks? Cable or Internet?
  - Common carriage?
  - Choice of layer to regulate as common carrier determine competition for:
    network providers, service providers, attachable de
- Cable TV model
  - local monopoly
  - one-way flow of information
  - single provider for transport + content
- Internet model
  - highly decentralized
  - multidirectional information flow
  - transport and content separated