Emerging Trends for the Millennium: Communications Technology

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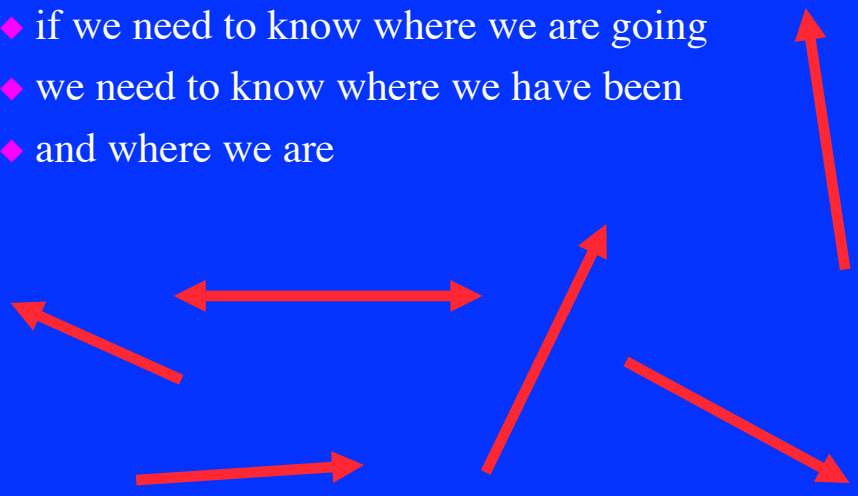
Vectors

- if we need to know where we are going
- we need to know where we have been
- and where we are

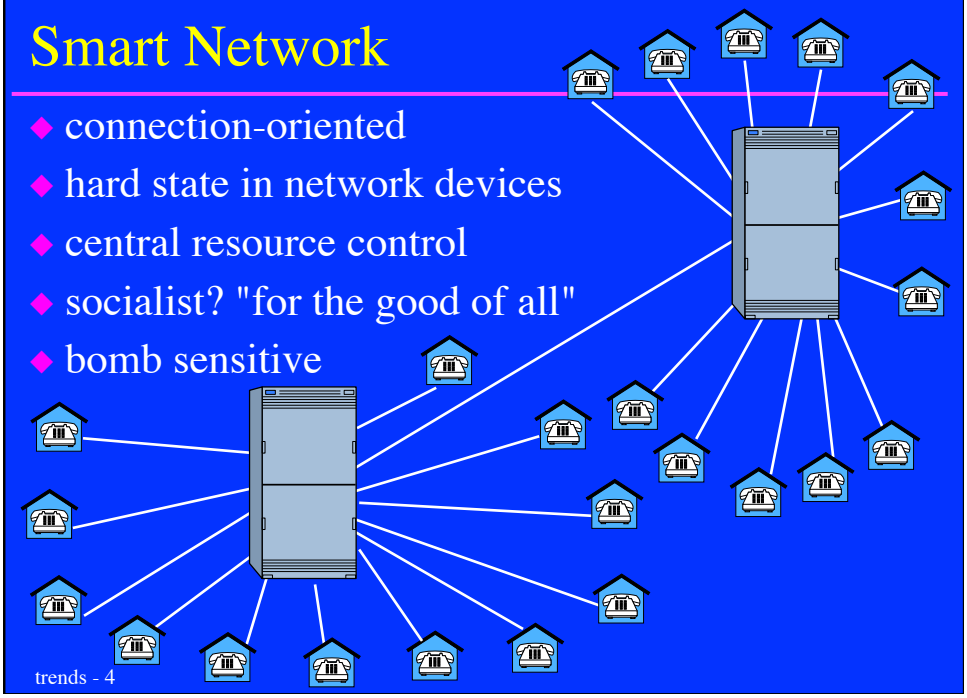


In the Beginning

- in the beginning (and now)
- there was (is) philosophy
  - or is that religion?
- smart network vs. smart edges
- centralized vs. distributed

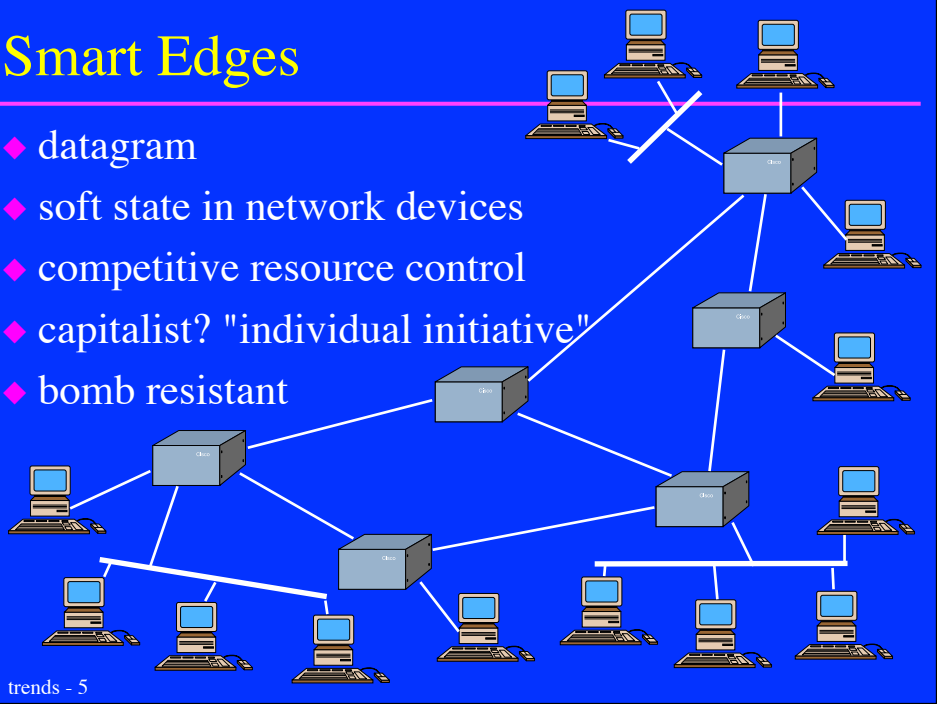
Smart Network

- connection-oriented
- hard state in network devices
- central resource control
- socialist? "for the good of all"
- bomb sensitive



Smart Edges

- datagram
- soft state in network devices
- competitive resource control
- capitalist? "individual initiative"
- bomb resistant



Survivability - Baran, 1964

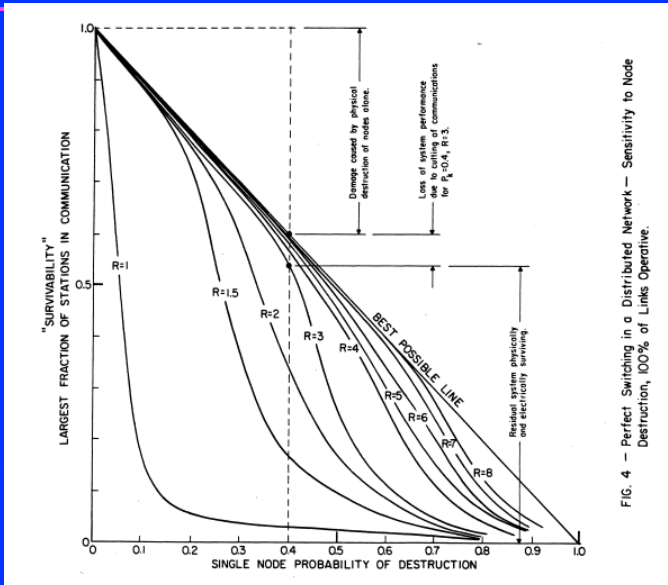
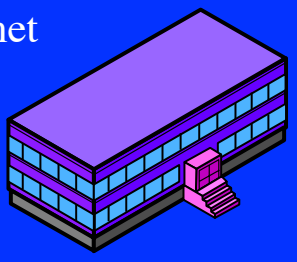
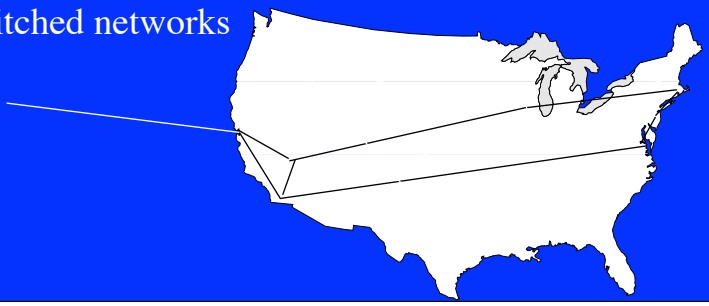


FIG. 4 — Perfect Switching in a Distributed Network — Sensitivity to Node Destruction, 100% of Links Operative.

The Safe Path

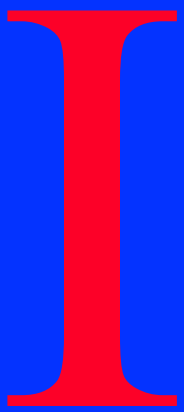
- traditional technologists: smart net
  - e.g., telephone system
  - circuit switched networks
- radicals: smart edges
  - e.g., ARPANET
  - packet switched networks





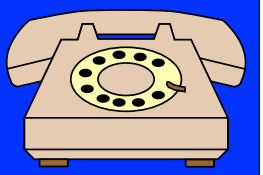
What is the Internet?

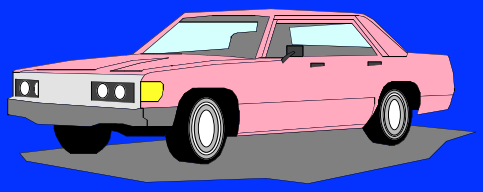
- separately identifiable data network
  - distinction changing
- hype topic
- Wall Street crack
- security worry
- reliability worry
- TCP/IP



Clue Check

- if you are asking "what is the application"
  you have already lost
- many looking for "the killer app"
- what was killer app for telephone
- what was killer app for auto?
- if you must have one: connectivity





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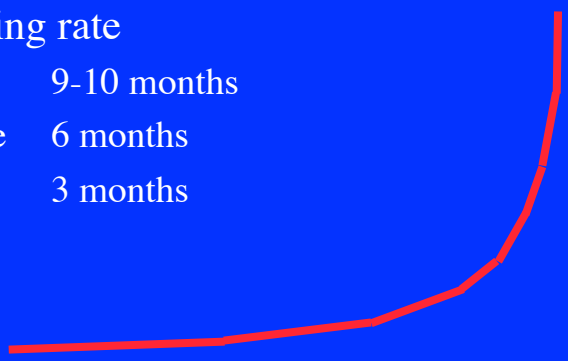
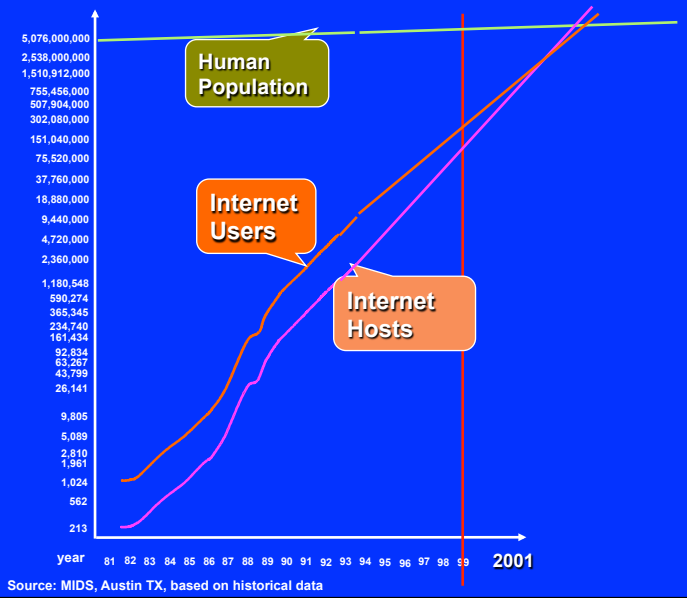
History

- ramp approaching vertical
- doubling rate
  - hosts 9-10 months
  - people 6 months
  - traffic 3 months



Future?



Source: MIDS, Austin TX, based on historical data

People vs. Silicon

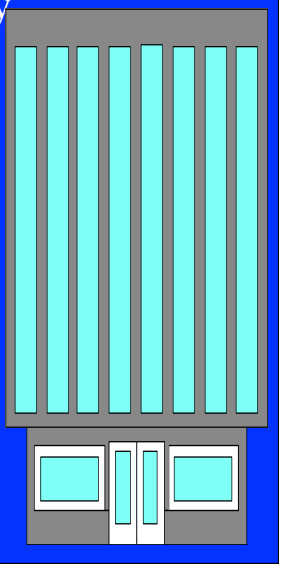
- why the Internet is not like the phone system
- phone system is scaled up as people do
  mostly
- Internet will scale up as computers multiply
  power controls
  toaster net

silicon cockroaches

- phone net growth rate will reduce as services move to web

Apparent Scale

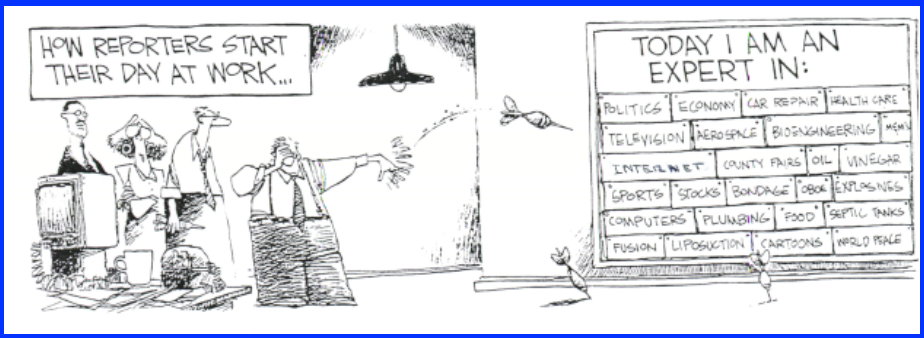
- on the ‘Net no one knows your puny’
- low cost of entry
- how can you tell if legit?
  - how can you tell if mail-order is legit?
- empower small company
- large company can lose big



Collapse of Net, GIF at 11

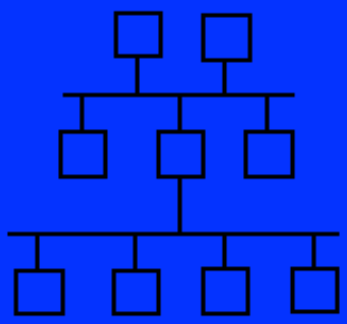
- Bob Metcalfe was making hay predicting doom
  - or was he?
- Bob was seen as predicting systemic collapse
  - but actually was predicting large scale outages
  - like with other technologies
- problem with trade & popular press
  - do not understand technology
  - over hype developments
  - over hype problems

How Reporters Start Their Day



Systemic Collapse

- the net is not a thing
  - it is a collection of things
- a network of networks
- very hard to bring down
  - too many nets
  - too many operators
  - too many operating procedures



Other Reasons Given for Collapse

- spam
- porn
- monopoly
- Microsoft (IBM, Netscape ...)
- traffic
- S/N ratio

What's Next?

- computers
- protocols
- applications
- structure
- security

Computers

- smaller
- cheaper
- faster
- more complicated == more support
- regulate types?
- incoming students know more about computers than senior faculty

Protocols

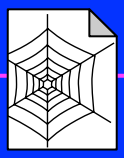
email, ftp
telnet, www

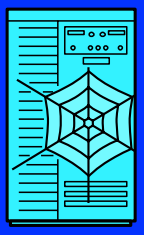
Ethernet
token ring
FDDI, ATM

- pretenders have failed
  X.25, OSI, SNA/APPN, IPX, ATM
- "common bearer service" important
- most common protocol in 2010?
  will be called IP
- convergence
  everything over IP

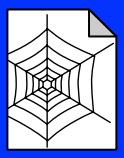
IP

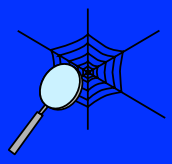
Applications

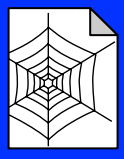


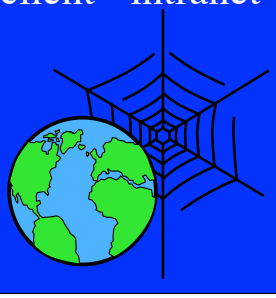


- the web filled an unseen hole
  - what other holes are there?
- lowered Internet entry requirements
  - mom can surf
  - dad can be a vendor
- now web is all too-ubiquitous client - intranet
  - the world is not all nails



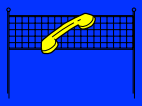






Applications

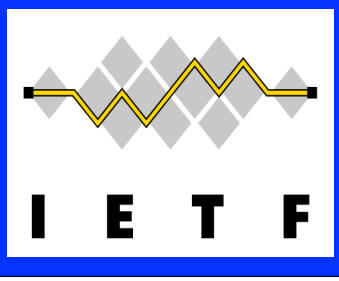
- only know a few of the apps of 2005
  - email
  - www
  - ftp
  - remote access
  - "buy" button



- but will these be in the top 10?

Differentiated Services

- is the Internet a one trick pony?
  - only 'best-effort' service
  - QoS to ISP means ' I will accept your packets"
- the Internet needs multiple "products"
  - better reliability for better money
- IETF (standards group) working on QoS technology
  - coming to your network soon



IP

- one of IP's strengths is that it can run over anything
  - barbed wire at 2,400 bps to glass at 2.4Gb
  - including wireless
- the world is not homogeneous
  - in any aspect, clearly not in networking
- IP can hide some of the differences

$$\frac{\text{IP}}{\text{anything}}$$

IP -- necessary and sufficient

Security

- today the security of the core of the net is quite good
- the edges are a problem
  - shared networks
- **very** good technology exists
- export control of encryption a problem
- complexity is a problem
- secure web very good
- but who can look at a student's email?
  - and if its encrypted?

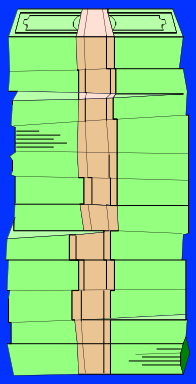
Will the Technology Structure Hold?

- traffic (both bits & routing info) are stressing current environment
- don't know what the glass will tie to
  - WDM & DWDM
- fog in the way of predicting
  - technology - who predicted the web?
  - regulations - son of CDA
  - prices - ISDN model

$ $ $ $ $ $ $

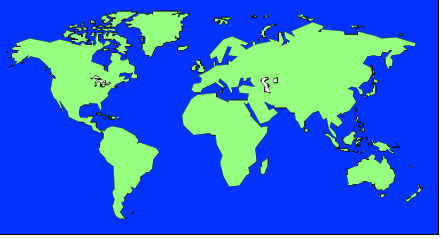
Money Funnies

- how do you regulate Internet money?
- how do you track Internet money?
- what is taxing jurisdiction?
- what is regulatory jurisdiction?
- anonymous cash
  only disclose if spent twice



Will the Social Structure Hold?

- the Internet is aggressively non-national
  the 1st amendment is a local ordinance
- threat to "order"
  as information sometimes is
- governments feel they must "protect" citizens
- Internet routes around censorship
- what authority does the FCC have?



Dumb Network

- smarts at edges not in network
  - i.e. in the PCs and servers not the network switches
  - reverse of telephone network
- means that it is easy to experiment
  - only end-systems need to be upgraded - e.g. web
- telephone net requires switch upgrade for new features
  - need to wait until the telco thinks it is worth it
- "the power of the Internet is chaos"

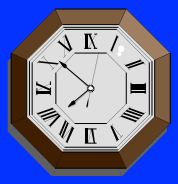
Impact on Education

- same potential for change that the research library created
- ubiquitous on-campus connectivity
  - dorms, wireless in classrooms ...
- distance learning
  - issues with faculty incentives
  - dilute brand name
  - impact on mid-sized colleges?
- content control?
  - what can be on a student web page?

Impact on Service Organizations

- like any other business
  - interacting with suppliers etc.
- equipment control
- visibility to customer
- customer input

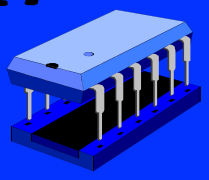
Businesses and the Internet



- shift in basic commerce interaction
  - to real-time over the ‘Net
- “just in time” ordering
- electronic ordering based on menus & history
- pure electronic billing & funds exchange
- but note no central management of application deployment
  - end users will deploy whatever applications they want to
  - this also means businesses do not need “approval” for their own applications

Equipment Control

- the Internet (or actually IP) is getting into everything
  - "toaster net"
- "embed the 'Net" - consortium
  - Internet on a chip
  - IP software in most significant equipment
    - pumps to ovens
    - monitor & control
- cheaper than individual connections to equipment
  - "every electrical device"

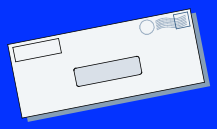


Visibility to Customer

- customers will expect to obtain all information they need via the 'Net
  - next week's menu
- may need to be part of a larger picture
  - e.g. Harvard "portal pages"
  - integrate data from many sources into unified view

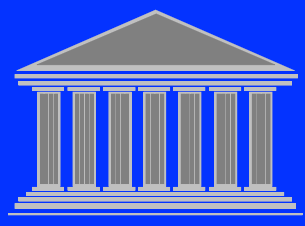
Customer Input

- customers will expect to do all interactions over the 'Net
  - pay bills, report problems, order catering, etc
  - work out details of events (timing, services to be offered)
  - menu requests?
- report on quality of services
- note - reports can be anonymous



Fundamental Issues

- on campus & global
- who says who makes the rules?
  - all kinds of rules
  - rule makers are problem-specific
- who pays for what?
  - e.g., universal access
  - browsers in libraries

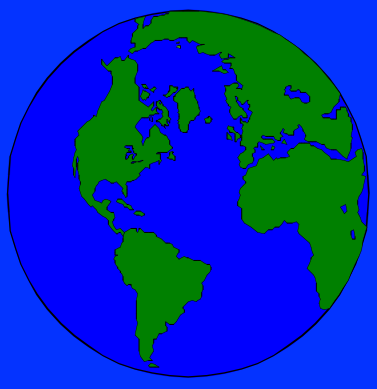


Impact on Society

- not the end of the nation state
  - but can change balance of power between government & citizen
- content, content, content
  - the dirty pictures are not the "real" problem
    - but an easy target - "protect the kids"
  - do not want to confuse citizens
- a "parent revolution"?

Complication

- remember the Internet is international

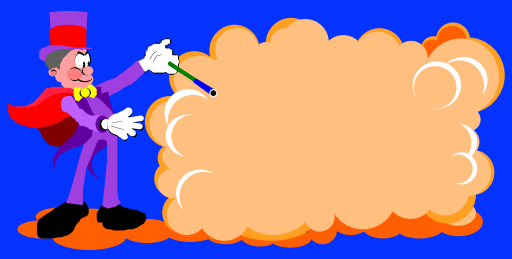


Futures

- it will be called IP
- it will be called the Internet
- convergence will have an impact
- it will always be "about to collapse"
- it will have differentiated services
- commerce will be normal
- continuous content control attempts
- continuous government attempts to "help"
  "too important" to left alone

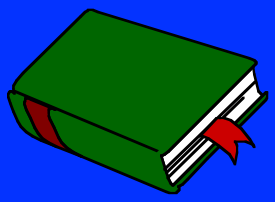
Where Are We?

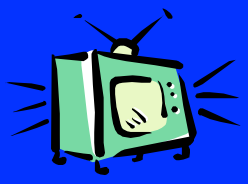
- not at end, end of beginning? or just starting?
- standing in '64 - today would be magic
- what will 2020 look like?
  hint - magic



Dreams

- can strengthen communities as well as threaten
- can empower individual entrepreneurs
  Nova Scotia books & Maine puppets
- broadcast TV vs. Internet



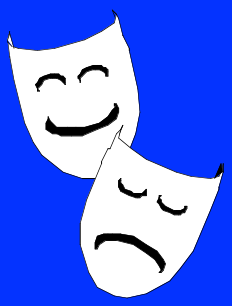


Worries

- can empower individual demagogues
- can enable big brother
- can destroy privacy
- can create information have-nots
- can exacerbate rich/poor split
- on the Net no one knows you are a nut
- on the Net no one knows you are a twit
  until you speak (too much)

Threat vs. Promise

- this data network can be both a threat & a promise
  - just like the auto
  - just like the telephone
- it will succeed at being both



we will see it together

Thank you