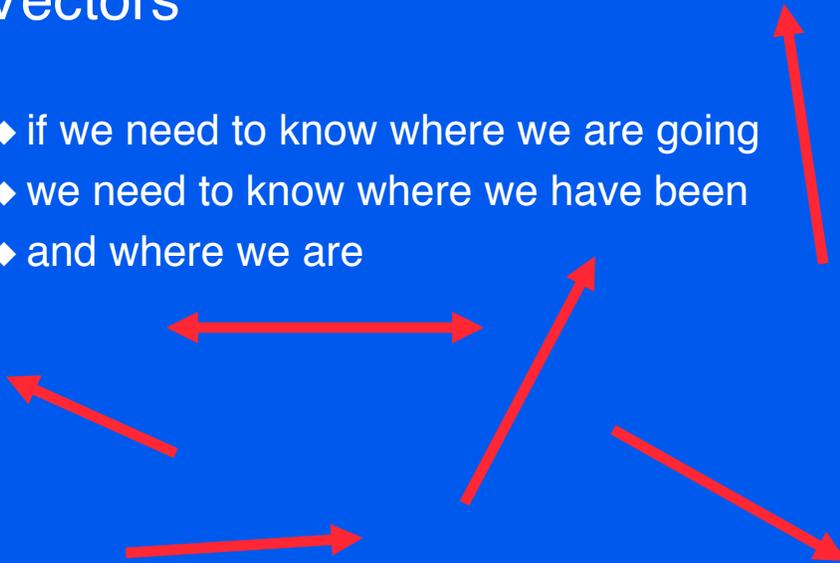


The Future of the Internet

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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



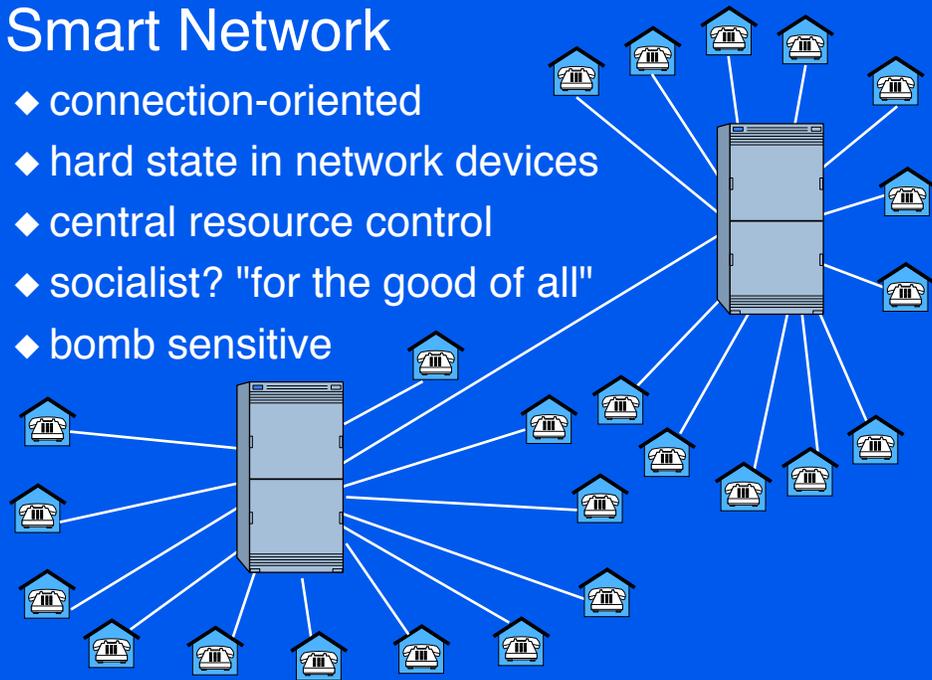
In the Beginning

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



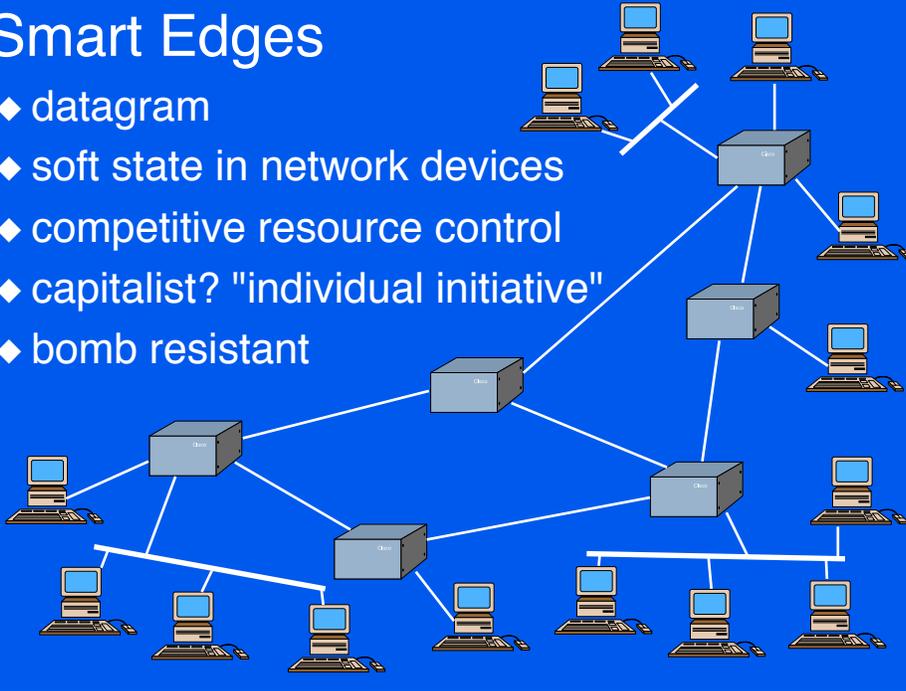
Smart Network

- ◆ 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

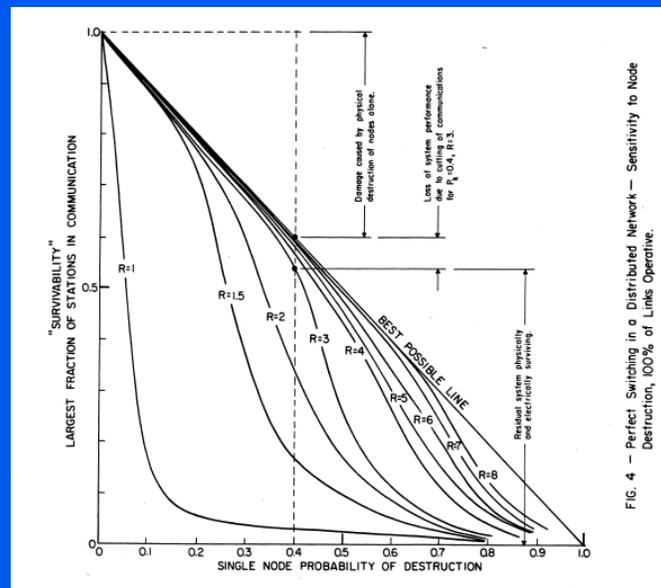
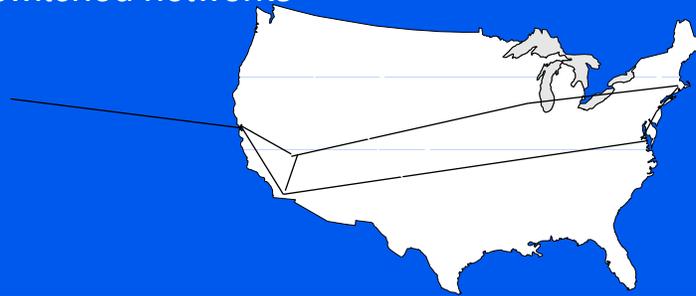
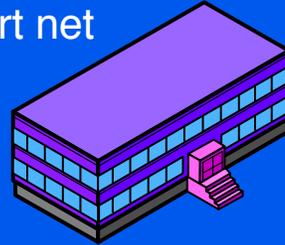


FIG. 4 - Perfect Switching in a Distributed Network - Sensitivity to Node Destruction, 100% of Lines Operative.

The Safe Path

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



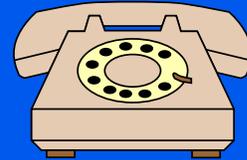
What is the Internet?

- ◆ separately identifiable data network
- ◆ 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

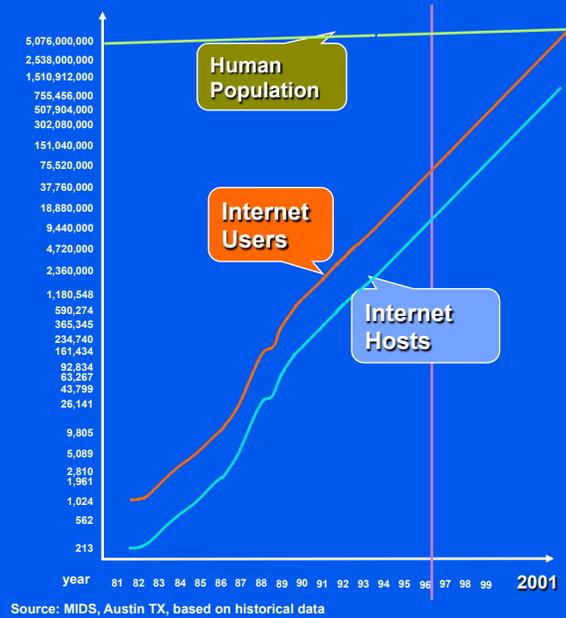


History

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



Future?



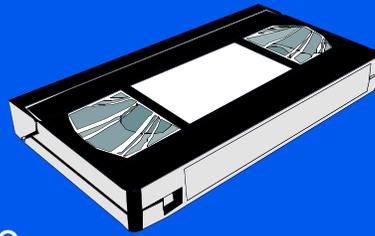
People vs. Silicon

- ◆ 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
- ◆ phone net growth rate will reduce as FAX & 800 move to web



The Business of Fun

- ◆ used to be that GIJ = "fun"
 - video on demand
 - distributed games
- ◆ can that work?
- ◆ with current technology - no
 - all current non-production entertainment revenue would not support infrastructure



The Fun of Business

- ◆ here today
 - MCI estimate - \$2B in '97
- ◆ electronic commerce
- ◆ trillion-ish \$ net-compatible
- ◆ FedEx, Walmart etc.



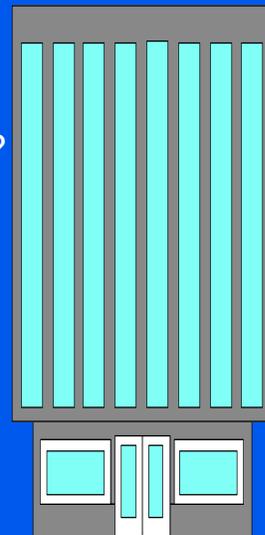
The Value of the Net Access

- ◆ should on-line services cost more?
- ◆ ATM vs. teller
- ◆ cost-based price vs. value-based price



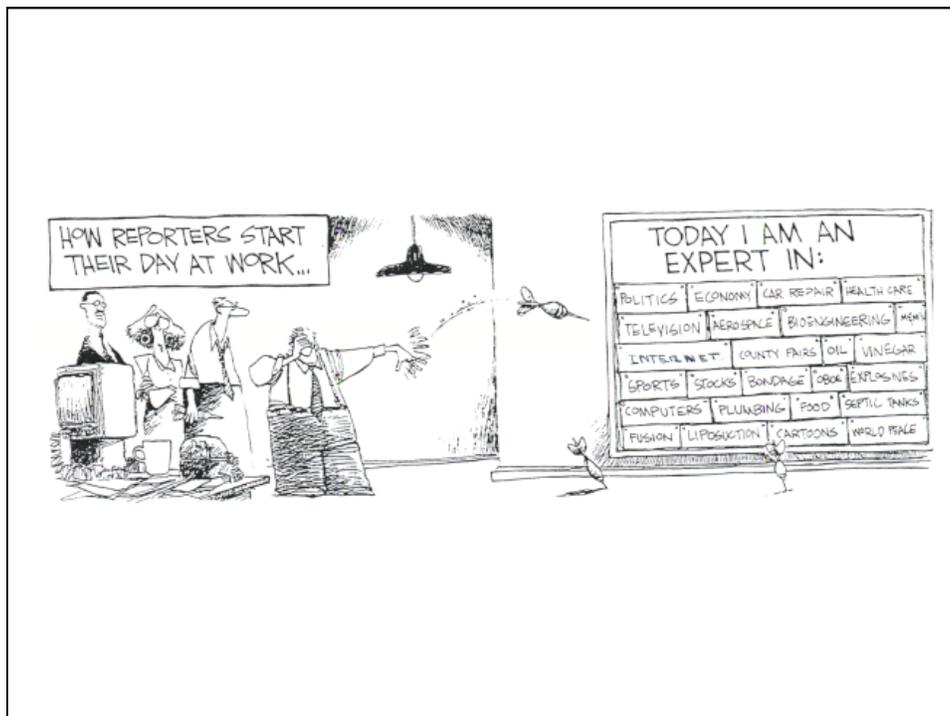
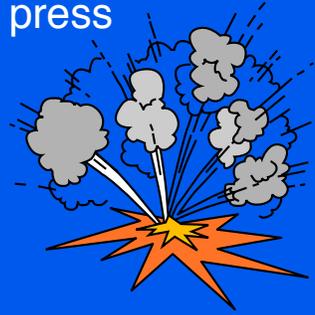
Apparent Scale

- ◆ 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
Microsoft estimate



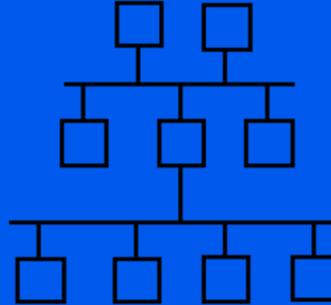
Collapse of Net, GIF at 11

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



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

Internet vs. Telephone System

- ◆ telco "system" going to where the Internet is
toward fragmentation
no Ma Bell anymore
- ◆ Internet will have consolidation in the core
but will still have many players at periphery
now about 4K ISPs
95% very small

What's Next?

- ◆ protocols
- ◆ applications
- ◆ structure
- ◆ security

Protocols

- ◆ pretenders have failed
X.25, OSI, SNA/APPN, IPX, ATM
- ◆ "common bearer service" important
- ◆ most common protocol in 2010?
will be called IP
- ◆ IPv6
will be slow adoption
few carrots seen
new addressing/routing
needed
China?

email, ftp
telnet, www

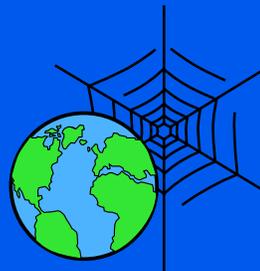


Ethernet
token ring
FDDI, ATM

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

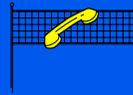
email

www

ftp

remote access

"buy" button



- ◆ but will these be in the top 10?

Are Voice & Video Special?

- ◆ broadcast - no
training, CNN etc.
just buffer the data stream

- ◆ interactive - yes

QoS (as in latency & latency variation) very important

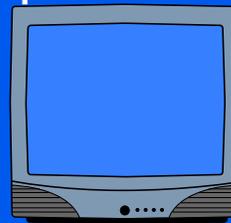
how to do this in a connection-less net?

RSVP tries to do this

- ◆ prediction: ATM will not help much

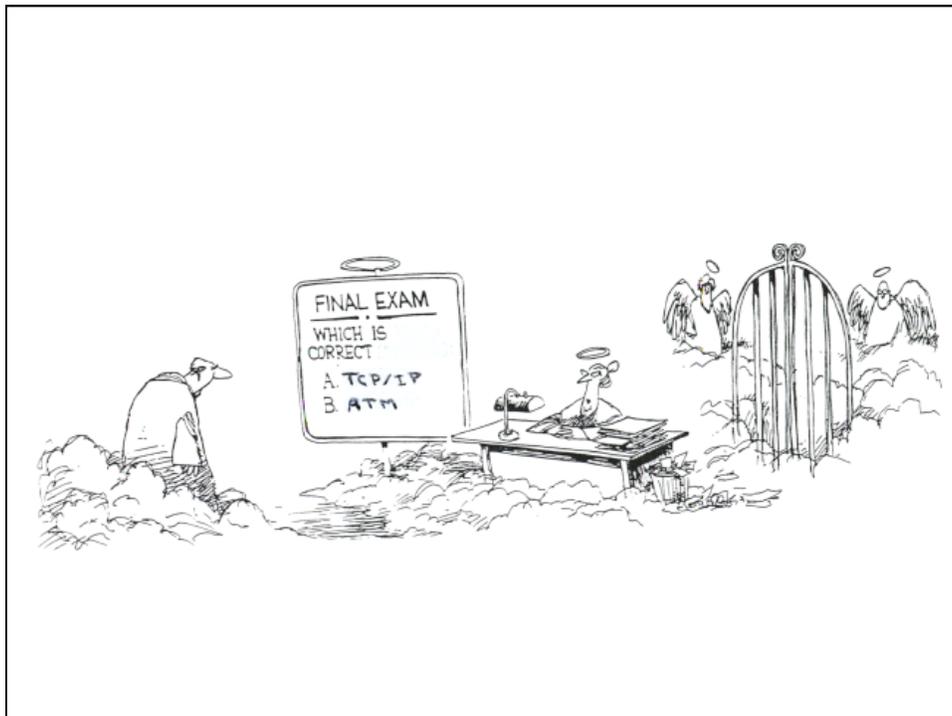
QoS needs to be end-to-end

desktop is almost all Ethernet (some token ring)



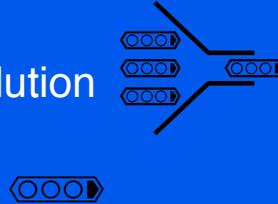
Differentiated Services

- ◆ 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
- ◆ is RSVP the IETF' s answer to ATM?
 - some are acting that way
 - designed for multicast - applied to unicast
 - bad scaling issues
- ◆ other differentiated services technologies needed - soon (RED on TOS bits?)



ATM

- ◆ started out as QoS-aware phone switch interconnects
- ◆ hijacked to be the common solution
- ◆ compromised along the way
(53 is the wrong size)
- ◆ ATM Forum (& trade press): future = ATM
- ◆ data traffic patterns not understood in original ATM design
traffic is fractile, not Poisson
- ◆ ATM will fail if it can not support IP well



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 ATM
- ◆ the world is not homogeneous
in any aspect, clearly not in networking
- ◆ IP can hide some of the differences

IP
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
- ◆ IPsec & IETF key management
 - can do much of the task
- ◆ secure web very good



Will the Technology Structure Hold?

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

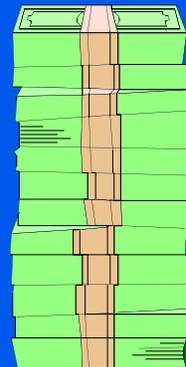


Can the Structure Scale?

- ◆ glass / interfaces not fast enough
gigabit router interfaces not here yet
- ◆ interconnects will be “stranded cable”
100s of parallel links \approx 1 path
- ◆ WDM an example
- ◆ fun in the routing domain
what does routing protocol see?
1 wire or N parallel wires?
- ◆ core has to be too fast to be smart

Money Funnies

- ◆ how do you regulate Internet money?
- ◆ how do you track Internet money?
- ◆ new instrument
- ◆ 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?
- 

Fundamental Issues

- ◆ 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

Futures

- ◆ it will be called IP
- ◆ it will be called the Internet
- ◆ it will always be “about to collapse”
- ◆ it will have differentiated services
- ◆ commerce will be normal
 - private data networks will not be
- ◆ continuous content control attempts

More Futures

- ◆ ubiquitous connectivity
- ◆ pipes from many sources
 - ISPs, telcos, cable, electric utility, wireless ...
- ◆ package deals (Internet “free” with cable)
- ◆ *Fred's bits to go* & *Bytes R us* will fade
- ◆ heterogeneous environments
- ◆ integrated at the end
 - separated in the core?
- ◆ ATM a part, not the whole

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

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