

# The Past, the Present, and the Future of the Internet

Is the Internet's future all used up?

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# Prediction 1



goods & services consumer

Disney - 1968

# Prediction 2

*“I don’t want to know the details,” Sandy interrupted. “I’m just assuming that you have the biggest-ever worm loose in the net, and it automatically sabotages any attempt to monitor a call to the ten nines. If I’d had to tackle the job, back when they first tied the home-phone service into the net, I’d have written the worm as an explosive scrambler, probably about half a million bits long, with a backup virus facility and a last-ditch infinitely replicating tail. It should just about been possible to hang that sort of tail on a worm by 2005.”*

*The Shockwave Rider* John Brunner - 1975

# The (Key) Idea

- then current design: circuit switched communications
- key idea: packets (aka datagrams) (1960s)
  - US: Leonard Kleinrock, Paul Baran
  - UK: Donald Davies, Peter Kirstein
- packets meant you did not need to be single minded
  - even if you were single wired
- but hard to provide service guarantees in a packet-based network.
  - “best efforts network”

# First Cause of the Internet

- ARPA (Sputnik response) wanted to share (the few & expensive) computers  
meanwhile (over in military land) Paul Baran wanted a survivable command & control network
- ARPA (Larry Roberts) had the money  
interpersonal message transmissions “not an important motivation for a network of scientific computers” (LR June 1967)  
purpose - sharing data, programs & computers (remotely)

# Not the Internet (Yet)

- the ARPANET was not the Internet (at first)  
network of computers, not a network of networks  
initial deployment 1969
- TCP/IP - aim: connect over existing dissimilar  
networks  
initial development mid 1970s  
deployment (on the ARPANET) Jan 1983  
actual start of **The Internet**

# An Aside: Naming

- 1970: “Internet”  
“a protocol for the Internet community” - RFC 60
- 1989: “Internet” trademarked  
Internet Inc.: *communications services, namely providing electronic data transmission services in the electronic banking field and retail marketing field - first use: 23 July 1984, first use in commerce: 23 July 1984*
- 1974: Catenet (Concatenated Network)  
Cerf & Kahn, 1st TCP paper  
(did not take)

# An Aside: Naming, contd.

- 1995: Federal definition of Internet

Federal networking Council - 10/24/1995

The Federal Networking Council (FNC) agrees that the following language reflects our definition of the term "Internet".

"Internet" refers to the global information system that --

(i) is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/ follow-ons;

(ii) is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/ follow-ons, and/or other IP-compatible protocols; and

(iii) provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein."

- note “globally unique address space”

# What Was the Internet (1983)

- links (from phone company & LANs) interconnecting IMPs (routers) & gateways  
no special services expected from links & LANs
- gateways (multi-port computers) on campuses
- transparent packet transport between hosts (through LANs, links & gateways)
- host decided what to send & how fast  
got speed hints (dropped packets) from network  
network = links, IMPs, gateways & LANs
- geek friendly interface **a few thousand users**

# End-to-End Argument (1984)

- *“The function in question can completely and correctly be implemented only with the knowledge and help of the application standing at the end points of the communication system. Therefore, providing that questioned function as a feature of the communication system itself is not possible.”*
- I.e., let the end do it  
or: smart networks are not helpful

# Implication of e2e Argument

- a generative environment  
you & I can experiment with new applications  
but so can Google & Amazon  
'a revolution from which revolutions are born'  
V. Hugo - Hunchback of Notre Dame
- do not need permission from carrier
- everyone buys connectivity  
users & service providers  
no special fee for service providers
- no binding between carriers and service providers  
I do not need to buy my email from my ISP

# Milestone



*"On the Internet, nobody knows you're a dog."*

Peter Steiner  
The New Yorker,  
5 July, 1993

# What Was the Internet (1993)

- about the same as in 1983
  - links, routers, LANs
  - transparent packet delivery
  - geek friendly interface (still mostly pre web)
  - globally unique addresses
- TCP had better start & congestion response behavior
- only 21 Internet-related patents issued

**a few million users**

# Also in 1993

- Classless InterDomain Routing (CIDR) RFC published
  - result of “running out of IP addresses” scare
    - actually only running out of Class B addresses
- governments mandated OSI protocols
  - US: GOSSIP
- start of IPng process
  - resulted in defining IPv6
    - an evolution of IPv4

# Also in 1993

- Asynchronous Transfer Mode (ATM) standards approved
- seen as underpinning for “broadband networks”
  - high speed data for the millions
- advanced QoS features that applications can make use of
- why does ATM matter?
  - it does not, but the assumptions behind ATM are a major factor in how some think about the Internet

# ATM, contd.

- 1994 INET meeting Prague  
IPng not assuming ATM was a “strategic error”
- 1996 ATM Year conference - NII panel  
telephone company & cable company future” use  
ATM to bring video on demand to customers -  
replace the Internet  
me: the Internet is the future and the future of ATM  
is tied to its ability to support IP
- but a whole new network  
“is ATM the last networking technology?”

# What Was the Internet (1997)

- wider understanding of the concepts  
e.g. “The Rise of the Stupid Network”
- little the same as in 1983  
links, routers, LANs
- some big changes  
less transparent packet delivery (firewalls)  
human friendly interface (web)  
fewer globally unique addresses (NATs)
- 400 Internet-related patents issued

**a 100 million users**

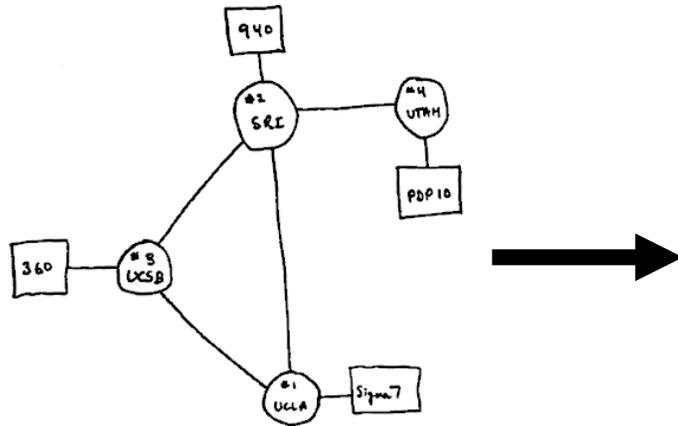
# ISPs

- commercial Internet started with NSFnet AUP
- Internet service providers (ISPs) provided TCP/IP connectivity using telephone wires & cable plant
  - first to their own customers, later they interconnected and offered “Internet” connectivity
  - understood Metcalfe's Law
- over time, most big ISPs died or became parts of phone or cable companies
- now most “always on” residential Internet service is from a big carrier

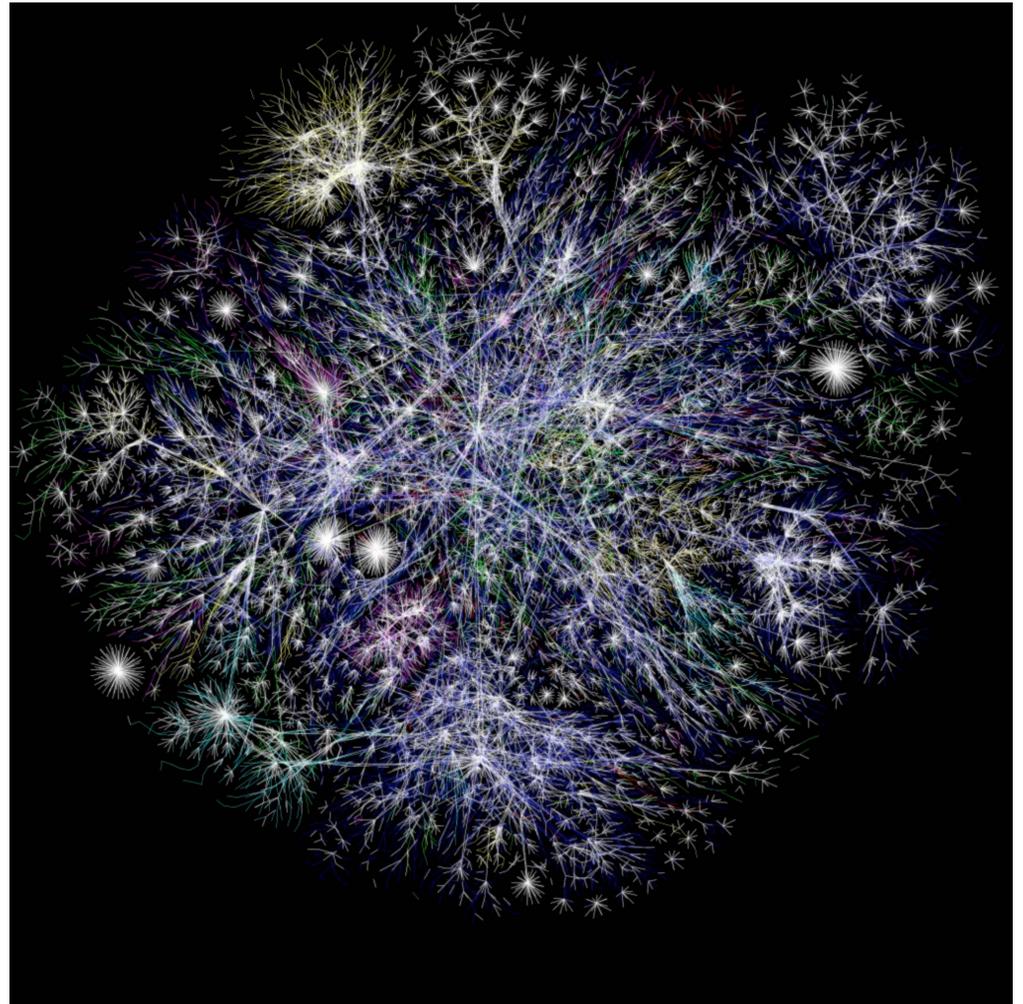
# Big Carrier Internet Model

- early telephone service assumption: users would communicate with service providers  
e.g., grocer, doctor, etc  
inter-person communication not all that important
- broadband networks service assumption: users watch video on demand  
inter-person communication not all that important  
looking for “killer aps”
- discussions about network neutrality are distorted by this model

# Development

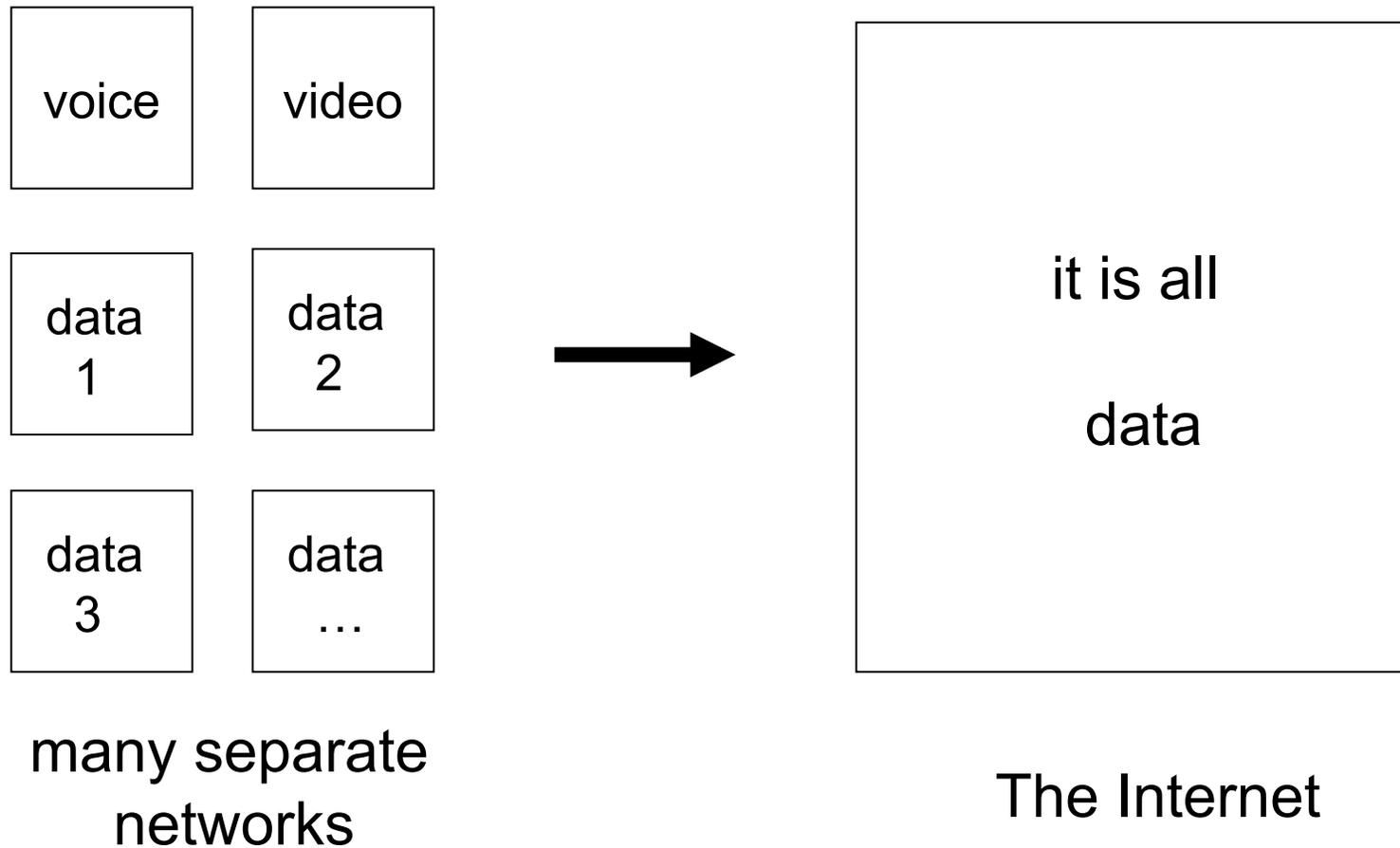


From  
(1969)



To  
(2008)

# At the Same Time



# What is the Internet (2008) #1

- little the same as in 1983
  - links, routers, LANs
- some big changes
  - still less transparent packet delivery (firewalls)
  - human friendly interface (web)
  - still fewer globally unique addresses (NATs)
- 23,500 Internet-mentioning patents issued (2007)
- carrier delivered

**> a billion users**

# Governance

- no governance to speak of until 1995, not much since then (in the US)
  - ad hoc processes, mostly set up by Jon Postel
- ISPs only required to register last year
  - part of CALEA extension to the Internet
- very different in other parts of the world
  - e.g., China ‘protecting its citizens’
- some governments worried about phone tax losses
  - some ban VoIP

# Why 1995?

- 1995 is when the NSF permitted NSI to charge for domain names
  - set off a feeding frenzy
  - domain names = trade marks == money
- major governance step in 1998 with creation of Internet Corporation for Assigned Names and Numbers (ICANN)
  - seen as the Internet manager - but it is not
  - “just” deals with IP addresses, top level domain names & protocol parameters

# Relating to the Old Order

- traditional telephony is one of the most regulated parts of business
  - international, national, state (US)
  - controls services, fees and coverage
  - e.g. FCC regulates phone #s
- the Internet is essentially unregulated
  - ICANN is a non governmental organization (NGO)
- government regulators & politicians do not understand
  - e.g., .iq top level domain for Iraq

# Old Order Striking Back?

- International Telecommunications Union (ITU) develops telecommunications standards, deals with international telecom tariffs, etc.  
countries are full members, others can also be members  
feels that it is a better place than ICANN to provide Internet governance
- I.e., government regulators want into the game

# Example Issue #1

- Internet is running out of addresses  
this time for real
- the free pool of IPv4 addresses will run out  
before 2012 at the current rate of assignment
- plan: convert world to IPv6  
hard, expensive, little reason other than not able to  
get addresses  
i.e., the have-nots must do  
but what can you reach with IPv6?

# Example Issue #1, contd.

- current address assignment process
- IANA runs the free pool (currently 36 /8s)
- IANA allocates blocks to regional registries
  - 5 registries (RIRs), each with a geographic area
- RIRs allocate blocks to ISPs following community developed policies
- general guidelines in RFC 2050
  - conserve address & conserve routing table space
- addresses are loaned and are not property
  - same as for phone numbers

# Example Issue #1, contd.

- note - no government involvement in process
- what to do when free pool runs out?  
proposals for a market in IPv4 addresses  
issues:
  - IPv4 addresses are not property
  - what about the routing table?
  - should RIRs be registering transfers?
- early IPv4 assignments were not categorized  
were they allocations or transfers?  
are they worth \$\$

# Example Issue #1, contd.

- early IPv4 allocations were big  
e.g., MIT got a /8 (17 M hosts)  
distribution seen as unfair in many places
- who gets to profit if there is a market  
can you sell outside your region?
- does anyone have authority over early assignments?

# Example #2

- the net neutrality question
- what is an ISP?
  - a transporter of bits?
  - a provider of higher level services?
- carriers say they need to value bits differently to raise the money needed to build new net
  - e.g., charge more for better delivery
  - e.g., of VoIP packets

## Example #2, contd.

- a non-neutral net is a gatekeeper  
new entrants may have to pay to play  
more than just buying for connectivity  
ISP could penalize non-partner services (e.g. VoIP)
- but a neutral net is a commodity service  
drive to the lowest price  
airline model?
- real competition can drive bloat out of carriers  
and produce better services for less  
e.g. cellular phone services

# Example #2, contd.

- network neutrality was top listed goal on Obama's technology web site
- regulations are not often a win
  - but may be the only path if little competition
  - a duopoly is not competition
- future all used up #1
  - technical regulations coming from people used to regulating phone & cable companies
  - e.g., FCC, congress

# Protecting the Citizens

- mandatory filtering of Internet accessible content
  - e.g. China, Germany (Pennsylvania tried)
- many excuses
  - protecting kids
    - e.g., CDA
  - tracking terrorists
    - record Internet usage, identify all users
  - stop lawbreakers
    - block child porn or gambling sites

# Protecting the Citizens, contd.

- CDA tried to block everything that was unsuitable for kids to see  
w/o a clear definition, not leaving it up to parents
- future all used up #2  
block anything anyone does not like

# Law

- what law applies & where?

Missouri MySpace abuser charged in LA

Chicago newspaper web site sued in Australia for liable

Yahoo Germany sued for stuff for sale in US

- is code law?

does the design of the limit what laws can say?

only if lawmakers understand code

# Law, contd.

- future all used up #3  
only permitted uses are the things that every jurisdiction on earth agree is OK

# What is the Internet (2008) #2

- what do those that use it think the Internet is?
- telecom geeks
  - world telecom infrastructure
    - replacing point to point circuits with packet networks
      - which can run pseudo wire point-to-point circuits
- carriers
  - Disney controlled TiVO
    - 'content is king'
      - you just want to watch what they want you to watch
- many users have a different view

Google™

# Another Milestone



*On the Internet, Google knows whose tail you have sniffed.*

# Big Brother, Inc.

- in Orwell, Big Brother was the government
- today it's everyone who has you in their database
  - in the US, essentially no rules - "they" own your data (or is it "they" own you?)
- future is all used up #4
  - there is no "you" where you are, you are everywhere

# Basic Questions

- 1994 I said there were two basic questions

“Who says who makes the rules?”

“Who says who pays for what?”

- these questions are still unanswered

# Root Problem

flow of \$

# Flow of Money

- carriers not part of value chain
  - yet need money to build & maintain infrastructure
- Internet does not have settlement model
  - ‘sender keeps’ economic model
  - money flows with connection in telco world
  - international link fees funky
    - half link charges
- future all used up #5
  - carriers convince regulators they have the answer

# What is the Internet?

- old FNC definition is not enough
- what do you expect to be able to send when you buy an Internet connection?  
any application?, just the web?, port 25?, VoIP?
- what do you expect to be able to receive when you buy an Internet connection?  
i.e., can you run a server
- who do you expect to be able to talk to when you buy an Internet connection?  
the world? the world other than the naughty bits?

# What is the Internet?, contd.

- what transfer rate do you expect when you buy an Internet connection?
  - enough for VoIP, enough for IPTV?
- how do you know your Internet service is working?
  - if you can not define what “working” means?
- future is all used up # 6
  - carriers get to define what “working” means

# Security

- “network security” is an oxymoron
- the network’s job is to deliver bits
- “security” (today) is an edge function  
in host, within enterprise, at edge of local network
- factoids
  - unpatched Windows XP box will be taken over  
within 15 min of being connected to the Internet  
on the average - Microsoft researcher
  - ~~Apple now recommends running a virus checker~~

# Security, contd.

- future is all used up #7  
    ISPs required to protect their customers

# How Important is the Internet?

- the Internet is the key pathway for a large percent of the developed world's commerce
- significant economic impact if the Internet were to “fail”
- amazing that, so far, it's still mostly unregulated
- governments see it as a “critical infrastructure” that needs to be redesigned to meet the needs placed on it
  - e.g. mandate ITU's NGN

# Internet Importance, contd.

- future is all used up #8  
the Internet is too important to be run by those that know what they are doing

# ATM (Again)

- mindset that led to ATM is still present  
the underpinning of the world's telecommunications  
needs to provide guaranteed & predictable  
behavior  
“best efforts” does not a guarantee make  
voice is too important for best efforts  
(don't bring up the cell phone)
- current invocation of ATM: ITU's Next  
Generation Network (NGN)  
end-to-end QoS (using MPLS - layer 2.5 circuits)  
session-based accounting etc.

# ATM (Again), contd.

- huge amount of effort going into NGN
- most features are carrier-centric
- some regulators (those that only understand circuit-based telephony) may see the NGN features as mandatory for “Internet service”  
e.g., not permitted to offer an Internet service that does not meet these requirements  
to “protect consumers”
- future all used up #9  
the answer is NGN, what was your question?

# 10 Key Decisions

- support existing networks
- datagram-based
- creating the router function
- split TCP and IP
- DARPA fund Berkeley to add TCP/IP to UNIX
- CSNET and CSNET/ARPANET deal
- NSF require TCP/IP on NSFnet
- ISO turn down TCP/IP
- NSF Acceptable Use Policy (AUP)
- minimal regulation

# An Improbable Chain

- any one of the decisions made differently could have produced a very different Internet

**the Internet's future is not all used up (yet)**

- we will have an Internet in 10 years
  - the communications network will be called that
- but it will not be The Internet
  - since it's not that today
- but, maybe, it will still be worthy of the name

