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

Peter Steiner
The New Yorker, 5 July, 1993

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

voice

video

data 1

data 2

data 3

data ...

many separate networks

it is all data

The Internet
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
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