

A History of the Internet

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BKC

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An Internet History

(1945) 1957-present

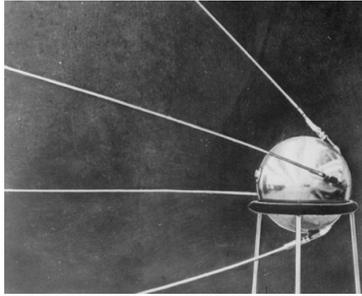
- A series of people and events that got us to today's Internet
 - Representative, not comprehensive
- What caused it to have the impact it has had
- What does the future look like?



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Sputnik

1957



- 4 October 1957
- 1st man made satellite
- Launched by Soviet Union
- Caused *hysteria*
- *The sky seemed almost alien*

Roger Launius *Sputnik and the Origins of the Space Age*

Lyndon B. Johnson

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Dwight David Eisenhower

1958



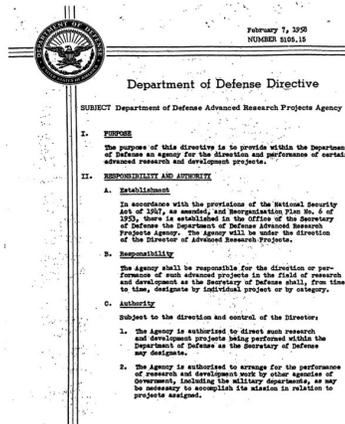
Dwight David Eisenhower

- U.S. President – 1953-1961
- January 1958: Eisenhower, following advice from his science advisor Jim Killian, reacted to Sputnik by establishing the *Advanced Research Projects Agency* (ARPA) within the U.S. Department of Defense



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ARPA Mission



- Official:
*The Agency shall be responsible for the direction or performance of such advanced projects in the field of research and development as the Secretary of Defense shall, from time to time, designate by individual project or by category.*¹
- Actual?:
*to prevent technological surprise like the launch of Sputnik*²

1: http://semanticvoid.com/docs/darpa_directive.pdf

2: <http://www.dtic.mil/cgi-bin/GetTRDoc>

Location=U2&doc=GetTRDoc.pdf&ADA433949 DoD Directive No. 5105.15 http

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Paul Baran

1960-64



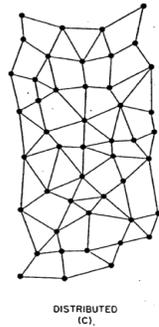
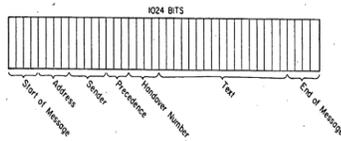
Paul Baran

- Hughes Aircraft & RAND Corp.
Funded by US Air Force
- 1960: *Reliable Digital Communications Systems Using Unreliable Network Nodes*
Reliability through redundancy
- 1962: *On Distributed Communications Networks*
Basic concepts of packet switched networks

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Paul Baran, contd.

1960-64



- “standardized message block”
 - Source & destination addresses
 - Precedence (QoS)
 - Payload
- Distributed network
 - Switching nodes (**routers**)
 - Store and forward
 - Redundant paths for reliability
 - Shortest-path hot-potato routing protocol

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Why message blocks?

1962-64

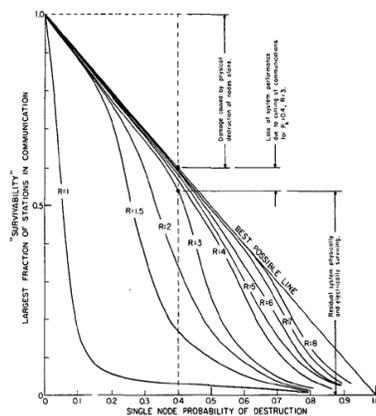


Fig. 4—Perfect switching in a distributed network: sensitivity to node destruction, 100 per cent of links operative.

- Communication at the time was circuit-based
- Circuit setup takes too much time relative to transmission length as links get faster
- Message-based networks also provide:
 - Multiplexing of different rate communications
 - Minimal message retransmission after failover to new routes
 - Resilience in the face of failure
 - Support for many applications (including speech)

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Baran's Goal¹



- Develop a command and control network that could survive a first strike nuclear attack
- Make design public so Russia would also have it
Almost all of Baran's documents were public
- AT&T: it will not work
- Did not get built
DCA would have had to do it and they did not accept the idea

1: <https://conservancy.umn.edu/handle/11299/107101>

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J.C.R Licklider

1960-68



J.C.R Licklider

- 1960: *Man-Computer Symbiosis*
How people could interact with computers
- 1962-3: *Intergalactic Computer Network* memos
Global data networks interconnecting computers
- 1962: argued for, created & initially led the ARPA Information Processing Techniques Office (IPTO)

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Robert (Bob) Taylor

1965-66



Bob Taylor

- Took over ARPA IPTO in 1965
- 1966: requested & was authorized to spend \$1M to build a data network to enable remote access to ARPA-funded timeshare computers
Became the ARPANET

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Donald Davies

1966-70



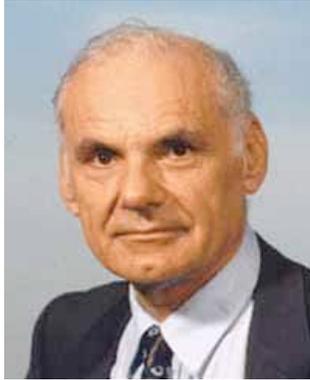
Donald Davies

- U.K. National Physical Laboratory
- 1966: proposed “packet” based communication between computers
Later introduced to Baran’s work

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Lawrence (Larry) Roberts

1966-73



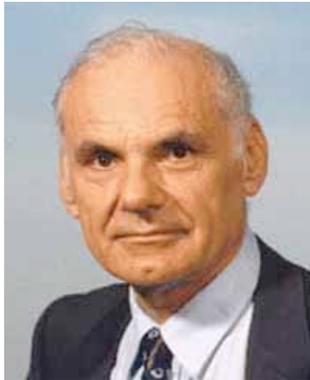
Larry Roberts

- Appointed by Taylor to develop ARPANET
- Decided to offload network processing to separate computers
(Idea from Washington University physicist Wesley A. Clark)
Interface Message Processor (IMP) (**router**)
- Decided did not want to use circuit switched networks

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Gatlinburg, TN ACM Meeting

1967



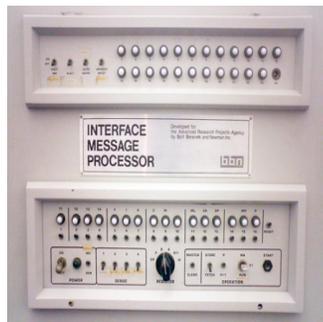
Larry Roberts

- Larry Roberts presented a paper on plans for the ARPANET
- Roger Scantlebury (from Davies's group) presented paper on packet switch networks
Afterward Scantlebury reminded Roberts about Baran's work
- Later Roberts met with Baran & Davies
- Roberts adopted packet switching for the ARPANET after 1967 meeting
- Took over ARPA IPTO in 1969

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ARPANET

1968-69

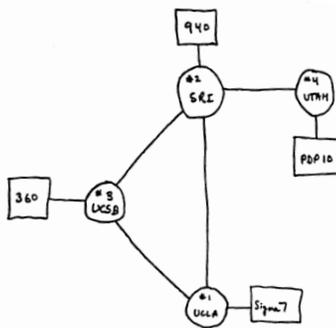


- 1968: RFQ for IMPs published
 - 4-node initial network
- 12 of the 140 companies asked submitted a bid
 - Neither IBM nor AT&T bid
- Bolt Beranek & Newman (BBN) won the contract
- August 1969: First IMP delivered to UCLA
- October 29 1969 – 1st message between nodes

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ARPANET, contd.

1969



- First 4 nodes installed
 - UCLA – Len Kleinrock Aug '69
 - Stanford Research Institute – Doug Engelbart – Oct '69
 - University of California, Santa Barbara – Glen Culler and Burton Fried – Nov '69
 - Early interactive on-line system
 - University of Utah – Ivan Sutherland – Dec '69

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ARPANET, contd.

1970-80



1970



1980

CSNET

- 1970 – east coast
First MIT, then BBN & Harvard
9 hosts
- 1973 – International
Norway & London
22 hosts + 18 TIPs
TIPs supported terminals
- 1980 – 200 hosts
20,000 users
Only those with government \$
- Big access change in 1983
To everyone associated with the university

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ARPANET Mission



The objective of this program is twofold:

- (1) To develop techniques and obtain experience on interconnecting computers in such a way that a very broad class of interactions are possible, and*
- (2) To improve and increase computer research productivity through resource sharing.*

By establishing a network tying IPT's research centers together, both goals are achieved.¹

1: <https://archive.org/stream/ResourceSharingComputersNetworks3/AAPA.txt>

- But, remember that the people paying the bills were the DoD

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Robert (Bob) Kahn

1968-76



Bob Kahn

- 1964: PhD from Princeton explored sampling theory
- 1968: Joined BBN & worked on IMP
- 1972: moved to ARPA IPTO
- Late 1972: organized demonstration ARPANET communications (20-nodes)

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Danny Cohen

1976



Danny Cohen

- Researched transporting speech over packet networks
- Realized that reliable transport protocols not good for speech
 - Delays introduced by reliability mechanism hurt understandability
- Used a reliability bypass option in ARPANET NCP
- 1978: demo video of speech over the ARPANET¹

1: https://www.youtube.com/watch?v=MGat1jRQ_SM

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Louis Pouzin

1971-76



Louis Pouzin

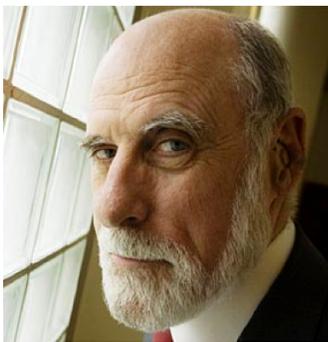
- French computer scientist
Spent time at MIT in mid 1960s
- 1972: designed CYCLADES network – a “catenet”¹
- 1974: Deployed 7 nodes
- 1976: 20 nodes
- “Pure datagram network”
No delivery assumptions
Reliability, order, duplication
Ran over France Telecom lines
- Put reliability responsibility at end points “end-to-end”

1: <https://www.rfc-editor.org/in-notes/ien/ien48.txt>

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Vinton (Vint) Cerf

1973-81



Vint Cerf

- Kahn realized that just interconnecting hosts over a single network did not scale
Needed a way to interconnect hosts on different networks
- He asked Vint Cerf for help
- They took into account the design of the CYCLADES network

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Internet Protocol

1974-81

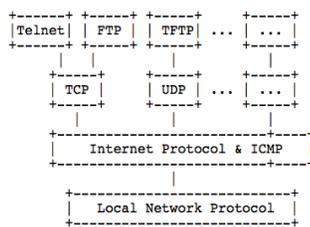


- Cerf & Kahn developed a datagram-based “Internet Protocol” suite
- Used Pouzin’s end-to-end concept
- Multiple layers
 - Application layer (e.g. telnet)
 - Transport layer (e.g. TCP)
 - Internet layer (IP)
 - Local network layer (e.g. Ethernet)

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TCP/IP

1974-81



Protocol Relationships
Figure 1.

TCP/IP

- Kahn & Cerf:
 - 1974: Internet Transmission Control Program (ITCP)
 - Only provided a reliable service
 - Danny Cohen & others objected
 - 1980 & 81: Internet Protocol, Transmission Control Protocol & User Datagram Protocol
 - Provided both reliable and unreliable services
 - Added UDP in parallel to TCP

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End-to-End Principle

1981



Jerry Saltzer



David Reed



Dave Clark

- *End-to-End Arguments in System Design*
- Placing low level functions in the network is redundant and of little value compared to placing them in the end nodes

The ends know what they need, the network can't

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End-to-End Design

NETHEADS VS BELLHEADS

The most vicious battle on the Net today is a secret war between techies. At stake is nothing less than the organization of cyberspace.

It was a frequent observation among the laptop-toting 25-year-olds who crowded into the UC San Diego auditorium on an overcast morning last February that if a bomb were to go off right then, the entire Internet would collapse. It was the kind of braggadocio you hear among any large gathering of engineers, but, in this case, it was probably true.

The 250 engineers who filled the dark, wood-paneled auditorium during the two-day meeting of NANOG, the North American Network Operators' Group, were from America's largest Internet service providers - companies like UUNET, Netcom, and Sprint - and they possessed the self-confidence that comes from operating millions of dollars of bleeding-edge technology that the world increasingly depends on. They were the builders of a new age, and although lacking the brawn and defined cheekbones of the engineers in Soviet propaganda posters, they emanated the same heroic attitude of advancing civilization through Herculean struggles.

Rise of the Stupid Network

Why the Intelligent Network was once a good idea, but isn't anymore. One telephone company nerd's odd perspective on the changing value proposition

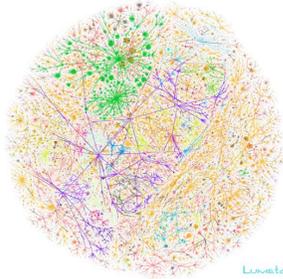
by
David Ienberg - isen@isen.com - www.isen.com

- “Stupid Network” just transports packets
Carrier does not own the customer
- Enables permissionless innovation
- The Internet is a Parent Revolution¹
Not the revolution itself

1: *Hunchback of Notre Dame* about the printing press

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Internet Technology & Required Control



Jon Postel



- Interconnected independent ISPs
 - Pair-wise ISP interconnection decisions - including payments
- No central control & little coordination are required
 - Protocol parameters
 - Bulk IP address assignments
 - Maintain DNS root zone file
- Now done by IANA (ICANN)

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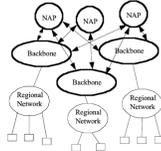
What did *they* think the Internet was?



- Irrelevant
 - Only a “research network”
 - No guarantees, no security
- Result: no regulations

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Connectivity Evolution (U.S.)



- ARPANET
- NSFNET/CSNet
- Regional Nets



- Rise of commercial ISPs
dialups migrate to always on
- Feds out of the business
- Rise of the carriers

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The Web

1991-



Tim Berners-Lee

<http://www.internetlivestats.com/total-number-of-websites/>

- 1991: Tim Berners-Lee releases web browser and server
- 1991: first web sites
- 1993: NCSA Mosaic released
- 1994: Netscape browser
- 1995: 23 K web sites
- 2000: 17 M web sites
- 2005: 65 M web sites
- 2010: 200 M web sites
- 2015: 1 B web sites

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What Made the Internet Important?

- End-to-end model & neutral networks
i.e., permissionless innovation
- Capacity increased with Moore's law & fiber deployment
- Did not design or change the Internet for a particular application – e.g. voice
The Internet is “good enough” for many applications
Particularly after bandwidth growth
- No regulations
i.e., permissionless deployment
- CDA blocked, but Section 230 OK



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Important Internet, contd.

Everything is bits

Video, audio, text, images, ...



Ada Lovelace – 1815-1852

It might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations – Ada Lovelace - 1843

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The Internet in the Future, technology?



Touch of Evil

[Quinlan](#): Come on, read my future.

[Tanya](#): You haven't got any.

[Quinlan](#): Hmm? What do you mean?

[Tanya](#): Your future's all used up. ¹

- TCP/IP
- ATM
- MPLS
- Per-flow queuing
- Next Generation Internet 
- 3/4/5G
- Information Centric Networking
- All-Intelligent Network
- . . .

1: <https://www.youtube.com/watch?v=UWtAZwxK5H0>

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Social Impact



- Enabler of dissidents
- Destroyer of morals
- Disrupter of society
- Disrupter of businesses
- Regulation needed?

*The High contracting Parties reserve the ability to stop any private communication that would appear to **endanger the security of the State**, or would be **violating the laws of the country, the public order or moral standards/values**, and shall immediately **notify the administration** of the country of origin*

Article 20 International Telegraph Convention 1865

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The Internet in the Future, Control?



Newt Gingrich

- The carriers have been trying to control the Internet ever since they figured out that it was not irrelevant
Same for governments & the ITU
The FCC tossing Title II has made carrier control of Internet legal
- A “controlled” Internet would not be The Internet

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The Internet in the Future, Control?



What achieved success was the very chaos that the Internet is. The strength of the Internet is that chaos. It's the ability to have the forum to innovate.¹

Will the forum continue?

1: Scott Bradner, March 22, 1996

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