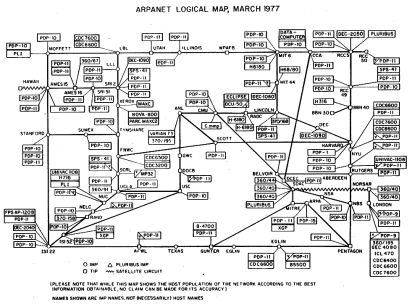
ARPANET

ARPANET	
 ARPANET logical map, March 1977	
Commercial?	No
Type of network	data
Location	USA
Protocols	NCP, TCP/IP
Established	1969
Funding	DARPA
Current status	defunct, superseded by NSFNET in 1990

The **Advanced Research Projects Agency Network** (**ARPANET**) was one of the world's first operational packet switching networks, the first network to implement TCP/IP, and the progenitor of what was to become the global Internet. The network was initially funded by the Advanced Research Projects Agency (ARPA, later DARPA) within the U.S. Department of Defense for use by its projects at universities and research laboratories in the US. The packet switching of the ARPANET, together with TCP/IP, would form the backbone of how the Internet works. The packet switching was based on concepts and designs by American engineer Paul Baran, British scientist Donald Davies[1][2] and Lawrence Roberts of the Lincoln Laboratory.[3] The TCP/IP communication protocols were developed for ARPANET by computer scientists Robert Kahn and Vinton Cerf.

History

Packet switching, today the dominant basis for data communications worldwide, was a new concept at the time of the conception of the ARPANET. Prior to the advent of packet switching, both voice and data communications had been based on the idea of circuit switching, as in the traditional telephone circuit, wherein each telephone call is allocated a dedicated, end to end, electronic connection between the two communicating stations. Such stations might be telephones or computers. The (temporarily) dedicated line is typically composed of many intermediary lines which are assembled into a chain that stretches all the way from the originating station to the destination station. With packet switching, a data system could use a single communications link to communicate with more than one machine by collecting data into datagrams and transmitting these as packets onto the attached network link, as soon as the link becomes idle. Thus, not only can the link be shared, much as a single post box can be used to post letters to different destinations, but each packet can be routed independently of other packets.[4]

The earliest ideas for a computer network intended to allow general communications among computer users were formulated by computer scientist J. C. R. Licklider of Bolt, Beranek and Newman (BBN), in April 1963, in memoranda discussing his concept for an "Intergalactic Computer Network". Those ideas contained almost everything that composes the contemporary Internet. In October 1963, Licklider was appointed head of the

Behavioral Sciences and Command and Control programs at the Defense Department's Advanced Research Projects Agency — ARPA (the initial ARPANET acronym). He then convinced Ivan Sutherland and Bob Taylor that this computer network concept was very important and merited development, although Licklider left ARPA before any contracts were let that worked on this concept.[5]

Ivan Sutherland and Bob Taylor continued their interest in creating such a computer communications network, in part, to allow ARPA-sponsored researchers at various corporate and academic locales to put to use the computers ARPA was providing them, and, in part, to make new software and other computer science results quickly and widely available.[6] In his office, Taylor had three computer terminals, each connected to separate computers, which ARPA was funding: the first, for the System Development Corporation (SDC) Q-32, in Santa Monica; the second, for Project Genie, at the University of California, Berkeley; and the third, for Multics, at MIT. Taylor recalls the circumstance: "For each of these three terminals, I had three different sets of user commands. So, if I was talking online with someone at S.D.C., and I wanted to talk to someone I knew at Berkeley, or M.I.T., about this, I had to get up from the S.D.C. terminal, go over and log into the other terminal and get in touch with them. I said, "Oh Man!", it's obvious what to do: If you have these three terminals, there ought to be one terminal that goes anywhere you want to go. That idea is the ARPANET".[7] Somewhat contemporaneously, several other people had (mostly independently) worked out the aspects of "packet switching", with the first public demonstration presented by the National Physical Laboratory (NPL), on 5 August 1968, in the United Kingdom.[8]

Creation

Len Kleinrock and the first Interface Message Processor.[9]

By mid-1968, Taylor had prepared a complete plan for a computer network, and, after ARPA's approval, a Request for Quotation (RFQ) was sent to 140 potential bidders. Most computer science companies regarded the ARPA–Taylor proposal as outlandish, and only twelve submitted bids to build the network; of the twelve, ARPA regarded only four as top-rank contractors. At year's end, ARPA considered only two contractors, and awarded the contract to build the network to BBN Technologies on 7 April 1969. The initial, seven-man BBN team were much aided by the technical specificity of their response to the ARPA RFQ – and thus quickly produced the first working computers. This team was led by Frank Heart. The BBN-proposed network closely followed Taylor's ARPA plan: a network composed of small computers called Interface Message Processors (IMPs: today called routers), that functioned as gateways interconnecting local resources. At each site, the IMPs performed store-and-forward packet switching functions, and were interconnected with modems that were connected to leased lines, initially running at 50kbit/second. The host computers were connected to the IMPs via custom serial communication interfaces. The system, including the hardware and the packet switching software, was designed and installed in nine months.[10]

The first-generation IMPs were initially built by BBN Technologies using a rugged computer version of the Honeywell DDP-516 computer configured with 24kB of expandable core memory, and a 16-channel Direct Multiplex Control (DMC) direct memory access unit.[11] The DMC established custom interfaces with each of the host computers and modems. In addition to the front-panel lamps, the DDP-516 computer also features a special set of 24 indicator-lamps showing the status of the IMP communication channels. Each IMP could support up to four local hosts, and could communicate with up to six remote IMPs via leased lines. The network connected one

computer in Utah with three in California. Later, the Department Of Defense allowed the universities to join the network for sharing hardware and software resources.

Misconceptions of design goals

Common ARPANET lore posits that the computer network was designed to survive a nuclear attack. In *A Brief History of the Internet*, the Internet Society describes the coalescing of the technical ideas that produced the ARPANET:

> It was from the RAND study that the false rumor started, claiming that the ARPANET was somehow related to building a network resistant to nuclear war. This was never true of the ARPANET, only the unrelated RAND study on secure voice considered nuclear war. However, the later work on Internetting did emphasize robustness and survivability, including the capability to withstand losses of large portions of the underlying networks.[12]

Although the ARPANET was designed to survive subordinate-network losses, the principal reason was that the switching nodes and network links were unreliable, even without any nuclear attacks. About the resource scarcity that spurred the creation of the ARPANET, Charles Herzfeld, ARPA Director (1965–1967), said:

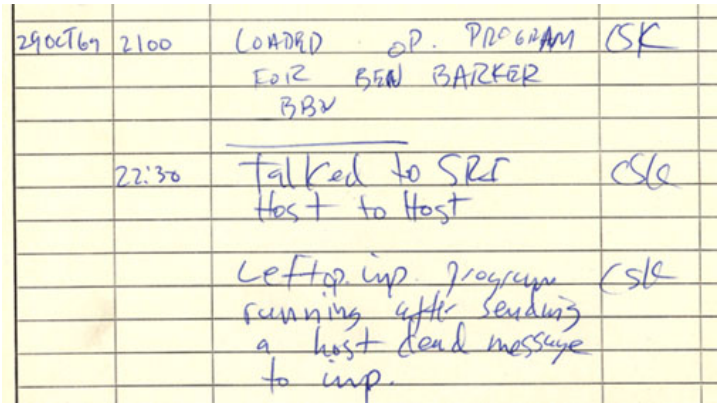
> The ARPANET was not started to create a Command and Control System that would survive a nuclear attack, as many now claim. To build such a system was, clearly, a major military need, but it was not ARPA's mission to do this; in fact, we would have been severely criticized had we tried. Rather, the ARPANET came out of our frustration that there were only a limited number of large, powerful research computers in the country, and that many research investigators, who should have access to them, were geographically separated from them.[13]

Packet switching pioneer Paul Baran affirms this, explaining: "Bob Taylor had a couple of computer terminals speaking to different machines, and his idea was to have some way of having a terminal speak to any of them and have a network. That's really the origin of the ARPANET. The method used to connect things together was an open issue for a time."[14]

ARPANET deployed

The initial ARPANET consisted of four IMPs:[15]

- University of California, Los Angeles (UCLA), where Leonard Kleinrock had established a Network Measurement Center, with an SDS Sigma 7 being the first computer attached to it;
- The Stanford Research Institute's Augmentation Research Center, where Douglas Engelbart had created the ground-breaking NLS system, a very important early hypertext system (with the SDS 940 that ran NLS, named "Genie", being the first host attached);



Historical document: First ARPANET IMP log: the first message ever sent via the ARPANET, 10:30 pm, 29 October 1969. This IMP Log excerpt, kept at UCLA, describes setting up a message transmission from the UCLA SDS Sigma 7 Host computer to the SRI SDS 940 Host computer

- University of California, Santa Barbara (UCSB), with the Culler-Fried Interactive Mathematics Center's IBM 360/75, running OS/MVT being the machine attached;
- The University of Utah's Computer Science Department, where Ivan Sutherland had moved, running a DEC PDP-10 operating on TENEX.

The first message on the ARPANET was sent by UCLA student programmer Charley Kline, at 10:30 pm on 29 October 1969, from Boelter Hall 3420.[16] Kline transmitted from the university's SDS Sigma 7 Host computer to the Stanford Research Institute's SDS 940 Host computer. The message text was the word *login*; the *l* and the *o* letters were transmitted, but the system then crashed. Hence, the literal first message over the ARPANET was *lo*. About an hour later, having recovered from the crash, the SDS Sigma 7 computer effected a full *login*. The first permanent ARPANET link was established on 21 November 1969, between the IMP at UCLA and the IMP at the Stanford Research Institute. By 5 December 1969, the entire four-node network was established.[17]

Growth and evolution

In March 1970, the ARPANET reached the East Coast of the United States, when an IMP at BBN in Cambridge, Massachusetts was connected to the network. Thereafter, the ARPANET grew: 9 IMPs by June 1970 and 13 IMPs by December 1970, then 18 by September 1971 (when the network included 23 university and government hosts); 29 IMPs by August 1972, and 40 by September 1973. By June 1974, there were 46 IMPs, and in July 1975, the network numbered 57 IMPs. By 1981, the number was 213 host computers, with another host connecting approximately every twenty days.[15]

In 1973 a transatlantic satellite link connected the Norwegian Seismic Array (NORSAR) to the ARPANET, making Norway the first country outside the US to be connected to the network. At about the same time a terrestrial circuit added a London IMP.[18]

In 1975, the ARPANET was declared "operational". The Defense Communications Agency took control since ARPA was intended to fund advanced research.[15]

In 1983, the ARPANET was split with U.S. military sites on their own Military Network (MILNET) for unclassified defense department communications. The combination was called the Defense Data Network (DDN).[19] Separating the civil and military networks reduced the 113-node ARPANET by 68 nodes. Gateways relayed electronic mail between the two networks. MILNET later became the NIPRNet.

Rules and etiquette

Because of its government ties, certain forms of traffic were discouraged or prohibited. A 1982 handbook on computing at MIT's AI Lab stated regarding network etiquette:[]

> It is considered illegal to use the ARPANet for anything which is not in direct support of Government business ... personal messages to other ARPANet subscribers (for example, to arrange a get-together or check and say a friendly hello) are generally not considered harmful ... Sending electronic mail over the ARPANet for commercial profit or political purposes is both anti-social and illegal. By sending such messages, you can offend many people, and it is possible to get MIT in serious trouble with the Government agencies which manage the ARPANet.[]

Technology

Support for inter-IMP circuits of up to 230.4 kbit/s was added in 1970, although considerations of cost and IMP processing power meant this capability was not actively used.

1971 saw the start of the use of the non-ruggedized (and therefore significantly lighter) Honeywell 316 as an IMP. It could also be configured as a Terminal Interface Processor (TIP), which provided terminal server support for up to 63 ASCII serial terminals through a multi-line controller in place of one of the hosts.[20] The 316 featured a greater degree of integration than the 516, which made it less expensive and easier to maintain. The 316 was configured with 40 kB of core memory for a TIP. The size of core memory was later increased, to 32 kB for the IMPs, and 56 kB for TIPs, in 1973.

In 1975, BBN introduced IMP software running on the Pluribus multi-processor. These appeared in a small number of sites. In 1981, BBN introduced IMP software running on its own C/30 processor product.

In 1983, TCP/IP protocols replaced NCP as the ARPANET's principal protocol, and the ARPANET then became one subnet of the early Internet.[21][22]

Shutdown and legacy

The original IMPs and TIPs were phased out as the ARPANET was shut down after the introduction of the NSFNet, but some IMPs remained in service as late as 1989.[23]

The *ARPANET Completion Report*, jointly published by BBN and ARPA, concludes that:

> ... it is somewhat fitting to end on the note that the ARPANET program has had a strong and direct feedback into the support and strength of computer science, from which the network, itself, sprang.[24]

In the wake of ARPANET being formally decommissioned on 28 February 1990, Vinton Cerf wrote the following lamentation, entitled "Requiem of the ARPANET":[]

> It was the first, and being first, was best,

```
but now we lay it down to ever rest.
```

> Now pause with me a moment, shed some tears.
> For auld lang syne, for love, for years and years

```
of faithful service, duty done, I weep.
```

> Lay down thy packet, now, O friend, and sleep.
>
> -Vinton Cerf

Senator Albert Gore, Jr. began to craft the High Performance Computing and Communication Act of 1991 (commonly referred to as "The Gore Bill") after hearing the 1988 report toward a National Research Network submitted to Congress by a group chaired by Leonard Kleinrock, professor of computer science at UCLA. The bill was passed on 9 December 1991 and led to the National Information Infrastructure (NII) which Al Gore called the "information superhighway". ARPANET was the subject of two IEEE Milestones, both dedicated in 2009.[25][26]

Software and protocols

The starting point for host-to-host communication on the ARPANET in 1969 was the 1822 protocol, which defined the transmission of messages to an IMP.[27] The message format was designed to work unambiguously with a broad range of computer architectures. An 1822 message essentially consisted of a message type, a numeric host address, and a data field. To send a data message to another host, the transmitting host formatted a data message containing the destination host's address and the data message being sent, and then transmitted the message through the 1822 hardware interface. The IMP then delivered the message to its destination address, either by delivering it to a locally connected host, or by delivering it to another IMP. When the message was ultimately delivered to the destination host, the receiving IMP would transmit a *Ready for Next Message* (RFNM) acknowledgement to the sending, host IMP.

Unlike modern Internet datagrams, the ARPANET was designed to reliably transmit 1822 messages, and to inform the host computer when it loses a message; the contemporary IP is unreliable, whereas the TCP is reliable. Nonetheless, the 1822 protocol proved inadequate for handling multiple connections among different applications residing in a host computer. This problem was addressed with the Network Control Program (NCP), which provided a standard method to establish reliable, flow-controlled, bidirectional communications links among different processes in different host computers. The NCP interface allowed application software to connect across the ARPANET by implementing higher-level communication protocols, an early example of the *protocol layering*

concept incorporated to the OSI model.[21]

In 1983, TCP/IP protocols replaced NCP as the ARPANET's principal protocol, and the ARPANET then became one component of the early Internet.[22]

Network applications

NCP provided a standard set of network services that could be shared by several applications running on a single host computer. This led to the evolution of *application protocols* that operated, more or less, independently of the underlying network service. When the ARPANET migrated to the Internet protocols in 1983, the major application protocols migrated with it.

- E-mail: In 1971, Ray Tomlinson, of BBN sent the first network e-mail (RFC 524, RFC 561).[28] By 1973, e-mail constituted 75 percent of ARPANET traffic.
- File transfer: By 1973, the File Transfer Protocol (FTP) specification had been defined (RFC 354) and implemented, enabling file transfers over the ARPANET.
- Voice traffic: The Network Voice Protocol (NVP) specifications were defined in 1977 (RFC 741), then implemented, but, because of technical shortcomings, conference calls over the ARPANET never worked well; the contemporary Voice over Internet Protocol (packet voice) was decades away.

ARPANET in film and other media

Contemporary

- Steven King (Producer), Peter Chvany (Director/Editor) (1972). *Computer Networks: The Heralds of Resource Sharing* [29]. Retrieved 20 December 2011. A 30 minute documentary film featuring Fernando J. Corbato, J.C.R. Licklider, Lawrence G. Roberts, Robert Kahn, Frank Heart, William R. Sutherland, Richard W. Watson, John R. Pasta, Donald W. Davies, and economist, George W. Mitchell.
- Scenario, a February 1985 episode of the U.S. television sitcom *Benson* (season 6, episode 20), was the first incidence of a popular TV show directly referencing the Internet or its progenitors. The show includes a scene where the ARPANET is accessed.[30]
- The long running British Science Fiction show, *Doctor Who*, can also lay claim to the first TV reference to an Internet-like network. In the 1966 serial, *The War Machine*s, a computer located in the newly opened Post Office Tower in London housed WOTAN (an acronym for Will Operated Thought ANalogue), the world's most intelligent computer. On 16 July 1966 (Computer Day), the major computers in the world were to be linked under WOTAN's control. These computers were located at facilities such as the White House, Cape Kennedy, ELDO, TESTAR, RN, Woomera and EFTA.[31][32]

Post-ARPANET

In *Let the Great World Spin: A Novel*, published in 2009 but set in 1974 and written by Colum McCann, a character named The Kid and others use ARPANET from a Palo Alto computer to dial phone booths in New York City to hear descriptions of Philippe Petit's tight rope walk between the World Trade Center Towers.

- In *Metal Gear Solid 3: Snake Eater*, a character named Sigint takes part in the development of ARPANET after the events depicted in the game.
- The *Doctor Who* Past Doctor Adventures novel *Blue Box*, written in 2003 but set in 1981, includes a character predicting that by the year 2000 there will be four hundred machines connected to ARPANET.
- There is an electronic music artist known as *Arpanet*, Gerald Donald, one of the members of Drexciya. The artist's 2002 album *Wireless Internet* features commentary on the expansion of the internet via wireless communication, with songs such as *NTT DoCoMo*, dedicated to the mobile communications giant based in Japan.

- In numerous *The X-Files* episodes ARPANET is referenced and usually hacked into by The Lone Gunmen. This is most noticeable in the episode "Unusual Suspects".
- Thomas Pynchon's 2009 novel *Inherent Vice*, set in southern California circa 1970, contains a character who accesses the "ARPAnet" throughout the course of the book.
- The viral marketing campaign for the video game *Resistance 2* features a website similar in design and purpose to ARPANET, called SRPANET.
- Episode 11 (season 2) of *Person of Interest*, "2πr," tells a story of an early hacker (heavily implied to be Finch) who somehow caused ARPANET to transform into the modern internet, using a homemade computer.

References

[1] http://www.thocp.net/biographies/davies_donald.htm

[2] http://www.internethalloffame.org/inductees/donald-davies

[3] .

[4] "Packet Switching History" (http://www.livinginternet.com/i/iw_packet_inv.htm), Living Internet, retrieved 26 August 2012

[5] "J.C.R. Licklider And The Universal Network" (http://www.livinginternet.com/i/ii_licklider.htm), Living Internet

[6] "IPTO – Information Processing Techniques Office" (http://www.livinginternet.com/i/ii_ipto.htm), Living Internet

[10] "IMP – Interface Message Processor" (http://www.livinginternet.com/i/ii_imp.htm), Living Internet

[15] "ARPANET – The First Internet" (http://www.livinginternet.com/i/ii_arpanet.htm), Living Internet

[21] "NCP – Network Control Program" (http://www.livinginternet.com/i/ii_ncp.htm), Living Internet

[22] "TCP/IP Internet Protocol" (http://www.livinginternet.com/i/ii_tcpip.htm), Living Internet

[23] "NSFNET – National Science Foundation Network" (http://www.livinginternet.com/i/ii_nsfnet.htm), Living Internet

[24] section 2.3.4

[27] *Interface Message Processor: Specifications for the Interconnection of a Host and an IMP* (http://www.bitsavers.org/pdf/bbn/imp/BBN1822_Jan1976.pdf), Report No. 1822, Bolt Beranek and Newman, Inc. (BBN)

[29] http://documentary.operationreality.org/2011/08/27/computer-networks-the-heralds-of-resource-sharing

[30] "Scenario" (http://www.imdb.com/title/tt0789851/), *Benson*, Season 6, Episode 132 of 158, American Broadcasting Company (ABC), Witt/Thomas/Harris Productions, 22 February 1985

[31] Lance Parkin and Lars Pearson (2012), *A history: an unauthorised history of the Doctor Who Universe* (http://madnorwegian.com/622/books/new-books/ahistory-an-unauthorized-history-of-doctor-who-third-edition/), 3rd edition, Des Moines: Mad Norwegian Press. ISBN 978-1935234111.

[32] For an explnation of the acronymns usd and a review of the Doctor Who serial, *The War Machines* see Vivien Fleming, "The War Machines", http://doctorwhomindrobber.wordpress.com/2013/07/25/the-war-machines/Retrieved 25 July 2013.

Further reading

- Norberg, Arthur L.; O'Neill, Judy E. (1996). *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1982*. Johns Hopkins University. pp. 153–196. ISBN 978-0801863691.
- A History of the ARPANET: The First Decade (http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA115440) (Report). Arlington, VA: Bolt, Beranek & Newman Inc.. 1 April 1981.
- Hafner, Katie; Lyon, Matthew (1996). *Where Wizards Stay Up Late: The Origins of the Internet*. Simon and Schuster. ISBN 0-7434-6837-6.
- Abbate, Janet (11 June 1999). *Inventing the Internet*. Cambridge, MA: MIT Press. pp. 36–111. ASIN B003VPWY6E (http://www.amazon.com/dp/B003VPWY6E). ISBN 0262011727.
- Banks, Michael A. (2008). *On the Way to the Web: The Secret History of the Internet and Its Founders*. APress/Springer Verlag. ISBN 1-4302-0869-4.
- Salus, Peter H. (1 May 1995). *Casting the Net: from ARPANET to Internet and Beyond*. Addison-Wesley. ISBN 978-0201876741.
- Waldrop, M. Mitchell (23 August 2001). *The Dream Machine: J. C. R. Licklider and the Revolution That Made Computing Personal*. New York: Viking. ASIN B00008MNVW (http://www.amazon.com/dp/B00008MNVW). ISBN 0670899763.
- "The Computer History Museum, SRI International, and BBN Celebrate the 40th Anniversary of First ARPANET Transmission" (http://www.computerhistory.org/press/museum-celebrates-arpanet-anniversary.html).

Computer History Museum. 27 October 2009.

Oral histories

- "Oral history interview with Robert E. Kahn" (http://purl.umn.edu/107387). University of Minnesota, Minneapolis: Charles Babbage Institute. 24 April 1990. Retrieved 15 May 2008. Focuses on Kahn's role in the development of computer networking from 1967 through the early 1980s. Beginning with his work at Bolt Beranek and Newman (BBN), Kahn discusses his involvement as the ARPANET proposal was being written and then implemented, and his role in the public demonstration of the ARPANET. The interview continues into Kahn's involvement with networking when he moves to IPTO in 1972, where he was responsible for the administrative and technical evolution of the ARPANET, including programs in packet radio, the development of a new network protocol (TCP/IP), and the switch to TCP/IP to connect multiple networks.
- "Oral history interview with Vinton Cerf" (http://purl.umn.edu/107214). University of Minnesota, Minneapolis: Charles Babbage Institute. 24 April 1990. Retrieved 1 July 2008. Cerf describes his involvement with the ARPA network, and his relationships with Bolt Beranek and Newman, Robert Kahn, Lawrence Roberts, and the Network Working Group.
- "Oral history interview with Paul Baran" (http://purl.umn.edu/107101). University of Minnesota, Minneapolis: Charles Babbage Institute. 5 March 1990. Retrieved 1 July 2008. Baran describes his work at RAND, and discusses his interaction with the group at ARPA who were responsible for the later development of the ARPANET.
- "Oral history interview with Leonard Kleinrock" (http://purl.umn.edu/107411). University of Minnesota, Minneapolis: Charles Babbage Institute. 3 April 1990. Retrieved 1 July 2008. Kleinrock discusses his work on the ARPANET.
- "Oral history interview with Larry Roberts" (http://purl.umn.edu/107608). University of Minnesota, Minneapolis: Charles Babbage Institute. 4 April 1989. Retrieved 1 July 2008.
- "Oral history interview with Stephen Lukasik" (http://purl.umn.edu/107446). University of Minnesota, Minneapolis: Charles Babbage Institute. 17 October 1991. Retrieved 1 July 2008. Lukasik discusses his tenure at the Advanced Research Projects Agency (ARPA), the development of computer networks and the ARPANET.

Detailed technical reference works

- Roberts, Larry; Marrill, Tom (October 1966). "Toward a Cooperative Network of Time-Shared Computers" (http://www.packet.cc/files/toward-coop-net.html). Fall AFIPS Conference.
- Roberts, Larry (October 1967). "Multiple computer networks and intercomputer communication" (http://www.packet.cc/files/multi-net-inter-comm.html). ACM Symposium on Operating System Principles.
- Davies, D. W.; Bartlett, K. A.; Scantlebury, R. A.; Wilkinson, P. T. (October 1967). "A digital communications network for computers giving rapid response at remote terminals". ACM Symposium on Operating Systems Principles.
- Roberts, Larry; Wessler, Barry (May 1970). "Computer Network Development to Achieve Resource Sharing" (http://www.packet.cc/files/arpa/comp-net-dev.html). Proceedings of the Spring Joint Computer Conference, Atlantic City, New Jersey.
- Heart, Frank; Kahn, Robert; Ornstein, Severo; Crowther, William; Walden, David (1970). "The Interface Message Processor for the ARPA Computer Network" (http://www.walden-family.com/public/1970-imp-afips.pdf). 1970 Spring Joint Computer Conference*AFIPS Proc.* **36**: 551–567.
- Carr, Stephen; Crocker, Stephen; Cerf, Vinton (1970). "Host-Host Communication Protocol in the ARPA Network" (http://tools.ietf.org/pdf/rfc33). 1970 Spring Joint Computer Conference*AFIPS Proc.* **36**: 589–598. RFC 33.
- Ornstein, Severo; Heart, Frank; Crowther, William; Russell, S. B.; Rising, H. K.; Michel, A. (1972). "The Terminal IMP for the ARPA Computer Network" (http://dx.doi.org/10.1145/1478873.1478906). 1972

Spring Joint Computer Conference*AFIPS Proc.* **40**: 243–254.
- McQuillan, John; Crowther, William; Cosell, Bernard; Walden, David; Heart, Frank (1972). "Improvements in the Design and Performance of the ARPA Network" (http://dx.doi.org/10.1145/1480083.1480096). 1972 Fall Joint Computer Conference*AFIPS Proc.* **41**: 741–754. Unknown parameter `|part=` ignored (help)
- Feinler, Elizabeth J.; Postel, Jonathan B. (January 1978). *ARPANET Protocol Handbook, NIC 7104*. Menlo Park: Network Information Center (NIC), SRI International. ASIN B000EN742K (http://www.amazon.com/dp/B000EN742K).
- Roberts, Larry (November 1978). "The Evolution of Packet Switching" (http://www.packet.cc/files/ev-packet-sw.html). *Proceedings of the IEEE* **66** (11): 1307. doi: 10.1109/PROC.1978.11141 (http://dx.doi.org/10.1109/PROC.1978.11141).
- Roberts, Larry (Sept 1986). *The ARPANET & Computer Networks* (http://www.packet.cc/files/arpanet-computernet.html). ACM.

External links

- "ARPANET Maps 1969 to 1977" (http://som.csudh.edu/cis/lpress/history/arpamaps/). California State University, Dominguez Hills (CSUDH). 4 January 1978. Retrieved 17 May 2012.
- Walden, David C. (February 2003). "Looking back at the ARPANET effort, 34 years later" (http://www.livinginternet.com/i/ii_imp_walden.htm). *Living Internet*. East Sandwich, Massachusetts: livinginternet.com. Retrieved 17 August 2005.
- "Images of ARPANET from 1964 onwards" (http://www.computerhistory.org/exhibits/internet_history/). The Computer History Museum. Retrieved 29 August 2004. Timeline.
- "Paul Baran and the Origins of the Internet" (http://www.rand.org/about/history/baran.html). RAND Corporation. Retrieved 3 September 2005.
- Kleinrock, Leonard. "The Day the Infant Internet Uttered its First Words" (http://www.lk.cs.ucla.edu/internet_first_words.html). UCLA. Retrieved 11 November 2004. Personal anecdote of the first message ever sent over the ARPANET
- "Doug Engelbart's Role in ARPANET History" (http://www.dougengelbart.org/firsts/internet.html). 2008. Retrieved 3 September 2009.
- "Internet Milestones: Timeline of Notable Internet Pioneers and Contributions" (http://www.juliantrubin.com/schooldirectory/internet_milestones_pioneers.html). Retrieved 6 January 2012. Timeline.
- Waldrop, Mitch (April 2008). "DARPA and the Internet Revolution" (http://www.darpa.mil/WorkArea/DownloadAsset.aspx?id=2554). *50 years of Bridging the Gap*. DARPA. pp. 78–85. Retrieved 26 August 2012.

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