The Internet: Past, Present and Future

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> "The ARPA theme is that the promise offered by the computer as a communication medium between people, dwarfs into relative insignificance the historical beginnings of the computer as an arithmetic engine"1

If one were to suggest one single occurrence which led to the creation of the Internet, it would be the Soviet Union's launch of the Sputnik satellite in 1957. This seminal incident in space exploration caused then American President Dwight David Eisenhower to appoint MIT President James A. Killian as a presidential assistant for science, and subsequently sparked the creation of a new department within the Department of Defense, named the Advanced Research Projects Agency (ARPA).[2]

ARPA was the answer to the rising American Cold War paranoia about military inferiority, fuelled not least by the Sputnik success. The agency was designed to perform long term high risk/high payoff research and development, and in this context placed great emphasis on the development of the at that time fledgling computer technology. It was felt by ARPA that too many resources had been allocated by public and private research in order to procure short-term advances in computer hardware and software. Instead, the Agency realized that "machines needed greater capa-

1 *The ARPANET Completion Report.* F. Heart, A. McKenzie, J. McQuillan & D. Walden. Washington, D.C., Jan. 4, 1978, p. III-24. Quoted from Hauben, Michael & Ronda Hauben. *Netizens:* On *the History and Impact of Usenet and the Internet.* Columbia University, 1995-96, Chapter 7, p. 52. URL: http://www.columbia.edu/~rh120/

2 Norberg, Arthur L. "Changing Computing: The Computing Community and DARPA." *IEEE Annals of the History of Computing,* Vol. 18, *2,* 1996, p. 41.

bility to interact with each other to gather relevant information, solve problems, anticipate data requirements, communicate effectively across distances, present information visually, and do all this automatically."[3]

"A Universal Network...:" J.C.R. Licklider's Vision

To expand the use of the computer ARPA founded the Information Processing Techniques Office (IPTO), and psychologist Joseph Carl Robnett Licklider was appointed as the first director. This choice proved to be a fruitful one, as Licltlider's overriding interest in human-computer interaction came in handy for the Department of Defense and ARPA, who in a 1960 survey had branded this area of crucial importance to the development of effective military command and control systems.[4]

But at the same time the appointment of the IPTO's first director also stressed the fact that many of ARPA's research landmarks would be beneficial to others beside the Department of Defense. Licltlider's main mission was not to design military tools but rather to further his personal vision of "Man-Computer Symbiosis," (reflecting his titling of an 1960 article), or as he expressed it in a 1988 interview: "I just wanted to make clear that I wasn't going to running battle planning missions or something. I was going to be dealing with the engineering substratum that [would] make it possible to do that stuff [command and control]."[5]

The Birth of Time-sharing

One of the many projects initiated by the IPTO was the further development of the computer process known as time-sharing. Pioneered by MIT

3 Ibid., p. 42.
4 Ibid., p. 44.
5 "The Project MAC Interviews," *IEEE Annals of the History of Computing*, Vol. *14*, 2, 1992, p. 24

scientists in 1961, it attempted to utililize the increasing power of the few computers available to the research community by making it possible for several people to use the same computer simultaneously. In July 1963 a contract was signed between MIT and the IPTO to implement what was named CTSS (Compatible Time-sharing System), and thus resources were allocated to aid the vision held by Licklider and other of his associates, a vision of interactive computing benefitting both research and educational systems as well as the world at large."

In retrospect, the development of the time-sharing process and philosophy was one of the factors that eventually sparked the creation of what would later become the Internet. However, the lack of innovation in the networking process itself caused many of its developers to name CTSS a failure, mostly because the hardware and software failed to live up to the expectation of being able to perform long-distance time-sharing tasks.[7] It was not possible for the time-sharing user to perform computing tasks on more than one remote system at a time, and the poor quality of telephone connections would often cause transmission errors.[8]

Packet switching

In July J.C.R. Licklider departed from the IPTO, but his successors continued the process of refining networking and time-sharing.

In 1966 a new networking project was initiated, and in the following year its leader, Laurence Roberts, presented a proposal for connecting all computers in the research community via dial-up telephone lines. At the same time the project became aware of a number of reports published in 1962 by Paul Baran of the Rand Corporation,[9] as well as unrelated but yet almost identical pioneering networking experiments conducted in the

6 Hauben (1995-96), p. 38-45.

7 Ibid.

8 O'Neill, Judy E. "The Role of ARPA in the Development of the ARPANET, 1961-1972." *IEEE Annals of the History of Computing*, Vol. 17, 4, 1995, p. 77.

9 Baran, Paul. "On Distributed Communication Networks." IEEE Transactions of the Professional Technical Group on Communications Systems. Volume CS-12, No. 1, March 1964.

U.K. by Donald Watts Davies of the National Physical Laboratory.[10] These concerned the possiblities of using what Davies termed a packet-switching process in order to secure the survivability of military command and control systems.

The principle of packet-switching relied on a peer-to-peer computer network, in which all the computers on a network had equal status and data-forwarding capabilities. If a user then wanted a set of data transmitted from one computer to another, regardless of the intervening distance, the transmitting computer would break up the data in small packets measuring only a few bytes.

These packets were unique, in the sense that they all contained information as to their point of origin, their destination on the network, as well as information which would enable the computer on the receiving end to reassemble the data set as soon as all packets had arrived.

When the IPTO realized the potential of this invention, they summoned a number of their existing networking contractors; RAND, University of California Santa Barbara (UCSB), Stanford Research Institute (SRI), University of Utah and University of California in Los Angeles (-UCLA), and by the summer of 1968 a set of specifications for a packet-switching network was approved by the IPTO.[11]

Later the same year a number of private companies were made to bid on the physical task of creating such a network, and in January 1969 the contract was awarded to Bolt Beranek and Newman (BBN), a Cambridge, Massachusetts company engaged in studies of acoustics, psychoacoustics, human-machine systems, and information systems.

At the same time work was undertaken to implement a set of communications settings (termed a protocol) which would enable the diverse number of computer hardware and operating systems available over such a network to communicate. Such protocols were essential to the success of such a project, effectively constituting a lingua franca among the connected computers.[12]

10 Hafner, Katie &Matthew Lyon. *Where Wizards Stay Up Late: The* ***Origins*** *of the Internet.* New York: Simon & Schnster, 1996, pp. 64-67

11 O'Neill (1995), p. 79.

12 Sterling, Bruce. "Short History of the Internet." 1993, p. 2. URL: gopher://gopher.isoc.org:70/00/internet/history/short.history.of.internet

On September 1, 1969 BBN delivered the first network computer, or IMP (Interface Message Processor) to UCLA, and shortly thereafter UCSB, SRI and University of Utah received their IMPs. As related by networking pioneer and then graduate student at UCLA Vinton Cerf, the hardware was an immediate success; "when they turned it (the IMP) on, it just started running."[13]

Although predated by the packet-switching experiments performed by Donald Watts Davies in 1968, ARPA thus succeeded in creating the first effective long-distance computer network, and it was appropriately named the ARPANET.

The Network Falls into Place

Despite the early vision formulated by Licltlider, the ARPANET experiment was to a large extent shaped by its status as a complete novelty on the computer science scene. Most of the people involved in the day to day work with implementing hardware and software were graduate students, and the personal accounts provided by participants suggested a true spirit of invention, but also of confusion: "No one had any answers, but the prospects seemed exciting. We found ourselves imagining all kinds of possibilities – interactive graphics, cooperating processes, automatic data base query, electronic mail – but no one knew where to begin."[14] In another context, ARPANET pioneer Steven Croclter describes this more succinctly: "During the initial development of the ARPANET, there was simply a limit as to how far ahead anyone could see and manage. The IMPs were placed in cooperative ARPA R&D sites with the hope that these research sites would figure out how to exploit this new communication medium."[15]

13 Cerf, Vinton (as told to Bernard Aboba). "How the Internet Came to Be," p. 1. URL: gopher://gopher.-isoc.org:70/00/internet/history/how.internet.came.to.be

14 J. Reynolds & J. Postel. RFC 1000. August 1987, p. 2. URL: http://info.internet.isi.edu:80/in-notes/rfc/-files/

15 E-mail message to COM-PRIV maling list (com-priv@psi.com). Subject: "Re: RFC 1000 (Partial response to part 1)" Nov. 27, 1993. Quoted *from* Hauben (1995-96), p. 54.

The most important task for the participants in this fledgling network was to ensure the stability of the communication protocols, a task undertaken by the so-called Network Working Group, which convened only a few months before the arrival of the first IMP. During the following year the group's participants succeeded in devising a protocol scheme whose basic philosophy is still applied in the Internet of 1996.

The idea was to have an underlaying protocol taking care of establishing and maintaining communication between the computers on the network, and a set of protocols which performed a number of tasks, such as remote log-in (Telnet) and file transfers (FTP), on top of this basic communications protocol, initially termed NCP (Network Control Protocol). This scheme was succesfully tested within the first year of the ARPANET's existence, and in October 1971, with the participation of 15 institutions, the network pioneers assembled at MIT for "a major protocol flyoff," an experiment which proved an almost total success (only one of the 15 sites involved failed to establish a connection).[16]

During the 1970s the ARPANET was constantly evolving in size and stability, and spawned a number of seminal developments. Among the most noteworthy was electronic mail, developed by Ray Tomlinson of BBN in 1972[17], and the establishment of a transatlantic connection in 1973 (reaching University College of London, U.K. and Royal Radar Establishment, Norway).[18]

In addition work was undertaken to improve the basic communication protocols and scale them according to the constant growth of the ARPANET, work which culminated in the introduction of a set of new communications protocols, TCP/IP (Transmission Control Protocol/Internet Protocol) in 1982.[19] At the same time the ARPANET team experimented with connecting various types of packet-switching networks, including satellite, radio, and cable-based networks.

16 RFC 1000 (1987), p. 4.

17 *Hafner* (1996), pp. 191-92.

18 Zakon, *Robert Hobbes. "Hobbes' Internet* Timeline v2.4a." February 22, 1996, p. 2. *URL:* http://info.-isoc.org/guest/zakon/Internet/History/HIT.html, *p. 2.*

19 *Ibid.*, p. 3.

The Opening of the Net

The years surrounding 1980 contained several important events, of which the two perhaps most important stand somehow ironic against each other; the initial military acceptance and usage of packet-switching networks taking place late in 1978, and the creation of Usenet in 1979.[20]

The military use of the ARPANET did not have any direct impact on the civilian use of the research network as such, but highlights the fact that the Internet of today was conceived as a military communications tool. Moreover, the military involvement in the ARPANET was terminated in 1983 when all military sites were integrated in the Defense Data Network created in 1982.[21]

Usenet, developed by Duke University and University of North Carolina students Tom Truscott and Jim Ellis, turned out to be the ultimate exponent for the physical anarchy of the ARPANET (no central command control, all connected computers being completely equal in their ability to transmit and receive packets). Utilizing the increasingly popular UNIX operating system developed at AT & T's Bell Laboratories in 1969,[22] and its derived communication protocol UUCP (Unix-to-Unix-Copy Protocol), Truscott and Ellis created a hierarchy of discussion groups which were distributed between a growing number of academic institutions via modems and phone lines. This hierarchy soon turned out to accommodate a wide number of interests, from computer programming to car maintainence, and enabled the participants to read and post information and opinions in what became known as Usenet Newsgroups.[23]

At first Usenet was a reflection of its status as a practically underground activity involving a number of graduate students, but soon a link was establish which enabled Usenet to receive content from the ARPANET mailing lists, a discussion forum whose content was spread via e-mail. One Usenet pioneer, Steve Bellovin, suggest that this had the consequence of extending the use of the ARPANET: "The impact of Usenet on the ARPANET was ... a (strong) catalyst to force re-examination ... on the strict policies against interconnection. UUCP mail into the ARPA-

20 Ibid.
21 Ibid., p. 4.
22 Hafner (1996), p. 250.
23 Ibid., pp. 78-82.

NET became a major force long before it was legit. And it was obviously known to, and ignored by, many of the Powers that Were."[24] At the same time Usenet and UUCP proved to be the network service and communications protocol which heavily contributed to the international growth of the internetworking principle. In the years 1982-84 Usenet connections were established to several European countries and Australia, and in 1987 the NNTP (Network News Transfer Protocol) was established in order to enable Usenet to be carried on the TCP/IP networks.[25]

The late Seventies saw two other important events which contributed to the eventual opening of the ARPANET into what essentially became a network of networks, an Internet. In May 1979 representatives from ARPA, The National Science Foundation, and computer scientists from six universities met to the discuss the possible creation of a dedicated research data network, and in 1982-83 CSNET was established.[26] From the beginning it was suggested that this new network should be linked to the ARPANET in a manner transparent to the users, and thus it was agreed to use the TCP/IP protocols.[27]

At the same time a number of other U.S. universities created BITNET, which from the outset connected IBM mainframes at participating data centres. BITNET proved to have an important multi-disciplinary effect on the research communities, especially when its e-mail based LISTSERV discussion forums were gated to other TCP/IP networks.[28]

NSFNET

The creation of CSNET and BITNET in the early Eighties signalled that

24 Bellovin, Steve. From sml,@ulysses.att.com Wed Oct 10 19:48 PDT 1990. From: smb@ulysses.att.com To: bjones@UCSD.EDU (Bruce Jones). Subject: Re: The List again :-) URL: ftp://weber.ucsd.edu/pub/usenet.history/nethist.901010.Z

25 Hauben (1995-96), pp. 91-94.

26 Hardy, Henry Edward. "The History of the Net." Master's Thesis, School of Communications, Grand Valley State University, Allendale, MI. V. 8.5, September 28, 1993, pp. 9-10.

27 Ibid.

28 Cerf, Vinton. "A Brief History of the Internet and Related Networks," p. 2. URL: gopher://gopher.isoc.org:70/00/internet/history/

the universities had begun to perceive networking as an essential tool for the research community, and this prompted the NSF to establish in 1986 a new trans-continental network based on the TCP/IP protocols, as well as creating 5 super-computing centres whose services were available to the research community at large.[29] The networlc typology of the NSFNET ensured that smaller academic institutions could afford to use its services; a high-speed network connection, referred to as the "baclbone," was established between the 5 super-computing centres and they in turn made their facilities available to universities in their region, effectively malting the networlc completely de-centralized.[30]

As noted by Ed Krol, the "most important aspect of the NSF's networking effort is that it allowed everyone access to the network."[31] NSF paid for the establishment of a connection to its network backbone only if a university honored the principle of extending its connection to other and often smaller educational institutions in the region.[32] This openness also initiated the commercial use of NSFNET, a development which first resulted in the establishment of e-mail links to commercial mail carriers (MCI Mail and Compuserve) in 1989, and one year later in the creation of the first commercial dial-up Internet access provider, The World (world.ste.com).[33]

A Net for All, and a Web Too

The years 1989-96 was another pivotal period for what was now effectively known as the Internet, stressing the fact that the original ARPANET had been superceded by a myriad of fast growing sub-networks operating in the U.S. and internationally (by October 1990 the number of networks was 2063, in January 1996 the number was 93,671). In 1989

29 Timeline, p. 4.

30 Krol, Ed."What is the Internet." RFC 1462, FYI 20., pp. 2-3. URL: gopher://ds.internic.net/00/fyi/fyi.txt

31 *Ibid., p. 3.*

32 *Ibid.*

33 Timeline, *p.* 6.

the ARPANET was decommisioned, and in April 1995 the NSFNET reverted back to a pure research network, leaving a number of private companies to provide Internet backbone connectivity.[34] At the same time the number of hosts as well as the network traffic grew at an enormous rate; in 1990 3 million hosts were counted, in July 1996 the number had risen to 12,881,000.[35]

This veritable explosion in network use, apart from the fact that the personal computer became a household item in the same span of time, can be attributed to the result of a research proposal submitted to the funding authorities of the European Laboratory for Particle Physics in Switzerland, CERN *(Conseil Europeen pour la Recherche Nucleaire).* The title was "WorldWideWeb: Proposal for a HyperText Project," and the authors were Tim Berners-Lee and Robert Cailliau.[36]

The World-Wide Web (also known as the WWW or Web) was conceived as a far more user-friendly and navigationally effective user interface than the previous UNIX-based text interfaces. The communications protocol devised for the WWW was termed HTTP (HyperText Transfer Protocol), hypertext being a concept conceived by Theodor Holm Nielsen in 1960.[37] In this context hypertext is essentially a navigational tool, linking data objects, be it text or graphics, together by association in what is effectively a web of pages, hence the use of the term "World-Wide Web." Berners-Lee and Cailliau describe the process as follows: "A hypertext page has pieces of text which refer to other texts. Such references are highlighted and can be selected with a mouse....When you select a reference, the browser [the software used to access the WWW] presents you with the text which is referenced: you have made the browser follow a hypertext link."[38]

The WWW prototype, developed on the NeXT operating system, was

34 Ibid., pp. 6-8.

35 bid., p. 9.

36 Bemers-Lee, Tim & Robert Cailliau. "WorldWideWeb: Proposal for a HyperText Project." Undated. URL: http://www.w3.org/pub/WWW/Proposal. (According to Robert Cailliau's "A Little History of the World Wide Web," October 3, 1995. URL http://www.w3.orglpub/WWW/History.html, the proposal was submitted in October 1990).

37 Zeltser, Lenny. "The World-Wide Web: Origins and Beyond." April 21, 1995, p. 2. URL: http://homepage.seas.upenn.edu/~lzeltser/WWW/

38 Bemers-Lee & Cailliau (1990), p. 2.

first demonstrated in December 1990, and on May 17, 1991 the WWW was let loose by granting HTTP access to a number of central CERN computers.[39] As soon as browser software became available for the more common operating systems such as Microsoft Windows and Apple Macintosh, this new tool was immediately picked up by the Internet community, and by 1993 an annual growth rate of 341,634% was noted.[40]

The World-Wide Web, the profiligation of Internet access for private individuals, as well as the increasing user-friendliness of the software necessary to master the Internet protocols contributed to the meteoric rise of network use in the 1990s.

The Future of Internetworking

Browsing through the orginal WWW proposal reveals an irony very characteristic to the development of the Internet, in the face of it's author's assertion that "the project will not aim to do research into fancy multimedia facilities such as sound and video."[41] In 1996 the present and future of the Internet, and the WWW in particular, points to a convergence of media types, and multimedia has indeed become the catch phrase of the day. Despite serious limitations in contemporary network capacity as far as full-motion sound and video are concerned, new technologies are revealed almost on a monthly basis, enabling increasingly interactive network experiences. This development is supplemented by a constant innovation in hardware; today's Internet backbones transmit data packets at a speed up to 200 megabits per second (by comparison, the NSFNET backbone of 1986 ran at the blazing speed of 56 kilobits per second). Today the modems of most Internet users run at a speed of 28.8 kbit/s and a digital connection (ISDN) can deliver at a speed of up to 128 kbit/s, but the possibility of using the fiber optic cables bringing cable TV to millions of homes in the Western Hemisphere for Internet data transmission opens

39 Cailliau (1995), p. 1.
40 Timeline, p. 7.
41 Berners-Lee & Cailliau (1990), p. 3.

up for private connections running at a speed of up to 10 Mbit/s.[42] Another new technology, ASDL, promises to use the existing telephone copper wires for even higher transmission speeds.[43]

But what will these network technologies deliver to the Internet user? In 1996 commercial Internet hosts have by far overtaken educational and governmental (in July 1996 there were 29% conmrnercial domains, as opposed to 9% educational),[44] and these commercial interests clearly perceive the Internet, and the WWW in particular, as a vehicle for online advertising and commerce. Hence the Net user of today can be aptly described as a consumer. The Internet is still a powerful medium for communication, and has in many ways fulfilled the vision of interactive computing which fuelled J.C.R Licltlider's imagination, but it remains to be seen whether it will be the democratizing medium of the 21st century, or merely become another static-filled television channel.

A Note on Citation

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42 Carl, Jeremy. "Firm Says It Has Solution to Cable Delivery's 'Upstream Crisis:' Startup to split data for easier travel." ***Web Week,*** Volume 2, Issue 4, April 1996.

43 Carl, Jeremy. "GTE, Microsoft Test High-speed Internet Access." ***Web Week,*** Volume 2, Issue 12, August 10, 1996.

44 Internet Domain Survey, July 1996. Conducted by Network Wizards, Inc. and available at URL http://www.nw.com/zone/WWW/report.html