Internet History

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ABSTRACT

This paper outlines and analyzes milestones in the history of the Internet. As technology advances, it presents new societal and ethical challenges. The early Internet was devised and implemented in American research units, universities, and telecommunication companies that had vision and interest in cutting-edge research. The Internet then entered into the commercial phase (1984-1989). It was facilitated by the upgrading of backbone links, the writing of new software programs, and the growing number of interconnected international networks. The author examines the massive expansion of the Internet into a global network during the 1990s when business and personal computers with different operating systems joined the universal network. The instant and growing success of social networking-sites that enable Netusers to share information, photos, private journals, hobbies, and personal as well as commercial interests with networks of mutual friends and colleagues is discussed.

Keywords: *ARPANET, History, ICANN, Innovation, Internet, Open Architecture, Packet Switching, Social Networking*

INTRODUCTION

History consists of a series of accumulated imaginative inventions.

– Voltaire

Floridi (2009, 2010) argues that we are now experiencing the fourth scientific revolution. The first was of Nicolaus Copernicus (1473–1543), the first astronomer to formulate a scientifically-based heliocentric cosmology that displaced the Earth and hence humanity from the center of the universe. The second was Charles Darwin (1809–1882), who showed that all species of life have evolved over time from common ancestors through natural selection, thus displacing humanity from the centre of the biological kingdom. The third was Sigmund Freud (1856–1939), who acknowledged that the mind is also unconscious and subject to the defence mechanism of repression, thus we are far from being Cartesian minds entirely transparent to ourselves. And now, in the information revolution, we are in the process of dislocation and reassessment of humanity's fundamental nature and role in the universe. Floridi argues that while technology keeps growing bottom-up, it is high time we start digging deeper, top-down, in order to expand and reinforce our conceptual understanding of our information age, of its nature, less visible implications and its impact on human and environmental welfare, giving ourselves a chance to anticipate difficulties, identify opportunities and resolve problems, conflicts and dilemmas.

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This essay focuses on the milestones that led to the establishment of the Internet as we know it today, from its inception as an idea in the 1950s until the early 21st Century. The varied and complex social and technological transformations we witness today have their roots in the way the Internet has been developed through research grants from the U.S. Department of Defense's Advanced Research Projects Agency. Scientists wished to maintain communication links between distant locations in the event that electrical rout had been destroyed. The early Internet was devised and implemented in American research units, universities, and telecommunication companies that had vision and interest in cutting-edge research. The program grew in the 60s and 70s, becoming a network of computers that transmitted information by "packet switching."

The network of computers was from the start an open, diffused and multi-platform network that up until the 1990s developed in the United States and then, within a few years, expanded globally in impressive pace and with no less impressive technological innovations the end of which we are yet to witness.

The interdisciplinary field of Technoethics is concerned with the moral and ethical aspects of technology in society. The Internet plays a crucial world in today's technology and society (Luppicini, 2010). In order to understand how the Internet became an integral part of our lives, it is crucial to examine its history and the major developments that took place from its modest infancy until its giant presence. In fifty years (1960-2010) the technology advanced rapidly. This has been an age of innovation where ideas have driven the development of new applications which, in turn, have driven demand. Then we witness circularity. New demands yielded further innovation and many more new applications – email, the world-wide-web, file sharing, social networking, blogs, skype. These were not imagined in the early stage of the net.

This essay examines milestones in the history of the Internet, how the Internet evolved from the Advanced Research Projects Agency (ARPA, 2004) in 1957, its formative years (1957-1984) until nowadays; from the early Internet devised and implemented in American research units, universities, and telecommunication companies that had vision and interest in cutting-edge research until a global phenomenon. I highlight the entry of the Internet into the commercial phase (1984-1989), facilitated by the upgrading of backbone links, the writing of new software programs and the growing number of interconnected international networks; the massive expansion of the Internet into a global network during the 1990s when business and personal computers with different operating systems joined the universal network; the instant and growing success of social networking -- sites that enable Netusers to share information, photos, private journals, hobbies and personal as well as commercial interests with networks of mutual friends and colleagues. The technology has transformed into a quotidian network for identifying, sharing and conveying information and ideas, exchanging graphics, videos, sounds and animation to hundreds of millions of Netusers around the world.

THE FORMATIVE YEARS

The history of the Internet started in the United States in the early 1960s. This was the Cold War period, when the world was bi-polar: The United States and the Soviet Union were competing in expanding their influence in the world, viewing each other with great caution and suspicion.

On October 4, 1957, the Soviet Union launched the first space satellite, Sputnik. The Sputnik success necessitated American reaction. It was a question of pride and leadership. The US Department of Defense responded by establishing the Advanced Research Projects Agency (ARPA, 2004),[1] designed to promote research that would ensure that the USA compete with and excel over the USSR in any technological race. ARPA's mission was to produce innovative research ideas, to provide meaningful technological impact that went far beyond the convention evolutionary developmental approaches, and to act on these ideas by developing

prototype systems.[2] One of the ARPA offices was the Information Processing Techniques Office (IPTO) which funded research in computer science designed to mobilize American universities and research laboratories to build up a strategic communication network (Command and Control Research) that would make available messaging capabilities to the government (Curran & Seaton, 2009; Conn, 2002).

A popular myth holds that the Department of Defense scientists thought that if the Soviet were capable to launch satellites, they might as well be capable to launch long-distance nuclear missiles. Because networks at the time relied on a single, central control function, so the myth goes, the main concern was networks' vulnerability to attack: Once the network's central control point ceased to function, the entire network would become unusable. The scientists wanted to diffuse the network so it could be sustained after attacking one or more of its communication centers (Schneider & Evans, 2007).[3] They had in mind a "decentralized repository for defense-related secrets" during wartime (Conn, 2002, p. xiii). However, the pioneers of the ARPA Network project argue that ARPANET was not 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."[4] Leonard Kleinrock, the father of Modern Data Networking, one of the pioneers of digital network communications who helped to build ARPANAET, explained that the reason ARPA wanted to deploy a network was to allow its researchers to share each others' specialized resources (hardware, software, services and applications). It was not to protect against a military attack.[5] And David D. Clark, Senior research scientist at MIT Laboratory for Computer Science who worked in the ARPANET project in the early 1970s, said he never heard of nuclear survivability and that there is no mentioning of this idea in the ARPA records from the 1960s. In a personal communication, Clark wrote:

I have asked some of the folks who pushed for the ARPAnet: Larry Roberts and Bob Kahn. They both assert that nobody had nuclear survivability on their mind. I was there from about 73, and I never heard it once. There might have been somebody who had the idea in the back of his mind, but 1) if so, he held it real close, and 2) I cannot figure out who it might have been. We know who more or less all the important actors were. (Sadly, Licklider has died, but I think I did ask him when he was still alive. I wish I had better notes.) So I am very confident that Baran's objective did not survive to drive the ARPA effort. It was resource sharing, human interaction… and command and control.[6]

In 1962, J.C.R. Licklider became the first director of the Information Processing Techniques Office. His role was to interconnect the Department of Defense's main computers via a global, dispersed network. Licklider articulated the vision of a "galactic" computer network—a globally interconnected set of processing nodes through which anyone anywhere can access data and programs.[7] In August 1962, Licklider and Welden Clark published the first Paper on the concept of the Internet titled "On-Line Man Computer Communication."[8] They saw communication network as a tool for scientific collaboration. Here the seeds for what would later become the Internet were planted.

Paul Baran (1964) of the RAND Corporation deserves particular attention not only because his research project created the myth that connected ARPANET to the development of a robust decentralized network that would enable the US a second-strike capability. Baran (1964) had been commissioned by the United States Air Force to study how the military could maintain control over its missiles and bombers in the aftermath of a nuclear attack. In 1964, Baran proposed a distributed scheme for U.S. telecommunications infrastructure with no central command or control point that would survive a "first strike." In the event of an attack on any one point, all surviving points would be able to re-establish contact with each other.[9] Note that Baran's research project came

about six years after ARPA was established. Lawrence G. Roberts, the principal architect of ARAPNET, wrote that the Rand work had no significant impact on the ARPANET plans and Internet history (Roberts, 1999).

In 1965, Donald Davies of the British National Physical Laboratory (NPL) began thinking about packet networks and coined the term "packet." In fact, at that period of time three scientists in three different locations were thinking independently about that same technology: Leonard Kleinrock was the first to develop the underlying principles of packet switching. His ideas, drafted at the MIT labs in 1961, constituted an important milestone in the development of the Internet.[10] Baran at RAND formulated the idea of standard-size addressed message blocks and adaptive alternate routing procedures with distributed control. And Davies thought similarly that to achieve communication between computers a fast message-switching communication service was needed, in which long messages were split into chunks sent separately so as to minimise the risk of congestion. The chunks he called packets, and the technique became known as packet-switching. Davies's network design was received by the ARPA scientists. The Arpanet and the NPL local network became the first two computer networks in the world using the technique (Kleinrock, 2008).[11]

The ARPANET was launched by Bolt Beranek and Newman (BBN) at the end of 1969.[12] BBN was commissioned to design four Interface Message Processors (IMPs), machines that would create open communication between four different computers running on four different operating systems, thus creating the first long-haul computer network and connecting between the University of California at Los Angeles (UCLA), the Stanford Research Institute (SRI) in Menlo Park, California, the University of California at Santa Barbara (UCSB), and the University of Utah which together comprised the Network Working Group (NWG).[13] A fifth ARPANET node was installed at BBN's headquarters. Each node consisted of an IMP, which performed the store-and-forward packet switching functions. Packet switching was a new and radical idea in the 1960s. Via ARPANET's Network Control Protocol (NCP), users were able to access and use computers and printers in other locations and transport files between computers. This was an investigational project that explored the most favorable way of building a network that could function as a trustworthy communications medium. The main hurdle to overcome was to develop an agreed upon set of signals between different computers that would open up communication channels, enabling data to pass from one point to another. These agreed upon signals were called *protocols*.

Essentially common grammatical tools of a technological language, protocols allow for conversations between any two computers so that anyone anywhere can search for and receive (or, conversely, create and send) text, graphic images, and audio and video files (Dubow, 2005).[14] The experimental project was based on open dialogue, where scientists posted Requests for Comments (RFC), on free exchange of information and ideas, on collaboration rather than competition.[15] There were no barriers, secrets or proprietary content. Indeed, this free, open culture was critical to the development of new technologies and shaped the future of the Internet. The NCP was a great success, enabling the linking together of researchers at remote sites. At the time, only hard-core computer scientists knew of this network's existence (Spinello, 2000).[16]

In those early days, the seeds of what will come to be known the Internet architecture and trade-marks were planted. The directors of ARPA's Information Processing Techniques Office (IPTO), Robert Taylor and Larry Roberts, allowed considerable freedom and flexibility in research. They imposed minimal requirements in terms of progress reports, meetings, site visits, oversight and other customarily bureaucratic mechanisms that are so prevalent in many organizations. Kleinrock (2008, p. 12) wrote: "We felt strongly that control of the network should be vested in all the people

who were using the Net and not in the carriers, the providers or the corporate world."

The network then expanded to other institutions, including Harvard, MIT, Carnegie Mellon, Case Western Reserve and University of Illinois at Urbana. Within sixteen months there were more than ten sites with an estimated 2,000 users and at least two routes between any two sites for the transmission of information packets (Slevin, 2000; Conn, 2002). ARPANET was the world's first advanced computer network using packet switching. Leonard Kleinrock wanted to develop a design methodology that would scale to very large networks, and the only way he thought was available to accomplish that was to introduce the concept of distributed control, wherein the responsibility for controlling the network routing would be shared among all the nodes, and therefore, no node would be unduly tasked.[17] This resulted in robust networks.

One of the major characteristics of the emerging network is innovation. One development quickly leads to another. In the early 1970s, scientists tried to overcome new problems. The new communication ideas, the experiments, the testing, and the tentative designs, brought about an endless stream of networks that were ultimately interlinked to become the Internet. Someone had to record all the protocols, the identifiers, networks and addresses and the names of all the things in the networked universe. And someone had to keep track of all the information that stemmed from the discussions. That someone was Jonathan B. Postel, a young computer scientist who worked at that time on the ARPA project at UCLA (Cerf, 1998). Postel devoted himself to building and running the Internet's naming and numbering structure. He proposed the top-level domains dot-com, dot-edu, and dot-net (Hafner & Lyon, 1998).[18] In those pioneering, unstructured and building years, Postel was, in effect, the Internet Assigned Numbers Authority (IANA). Postel was not elected to the position of responsibility he held in the Internet community; he was simply, in the words of the White House's Internet policy adviser, Ira Magaziner, "the guy they trust".[19]

Secondly, the ARPANET succeeded in connecting the computers used in different time-sharing systems. Now they wished to connect the packet switching network of the ARPANET with a satellite packet switching network and a packet radio packet switching network. In July 1970, the first packet radio ALOHANET, based on the concept of random packet transmission, was developed at the University of Hawaii by Norman Abramson and became operational. ALOHANET linked the University of Hawaii's seven campuses to each other and to the ARPANET. Based on this model, ARPA built its own packet radio network which was called PRNET (Ryan, 2011). At that same period of time, ARPA also developed a satellite network, called SATNET.

In 1971, UNIX operating system was developed at Bell Lab, quickly gaining the appreciation of many scientists. UNIX provides a suite of programs which makes the computer work. It is a stable, multi-user, multi-tasking system for servers, desktops and later on also for laptops.[20] In 1972, ALOHANET connected to the ARPANET and a commercial version of ARPANET, called TELNET, became the first Public Packet Data Service. The Telnet protocol was a relatively simple procedure. It was a minimal mechanism that permitted basic communication between two host machines.[21] Telnet applications allow users to log on and to operate remote computers. Such applications can, for example, be used to search and consult remote databases such as library catalogues.

A year later, in 1973, ARPANET was connected to international hosts. File transfer Protocol (FTP) came into existence and worked using a Client Server Architecture.[22] The file-transfer protocol specified the formatting for data files traded over the network. FTP made it possible to share files between machines. Moving files might seem simple, but the differences between machines made it very difficult. FTP was the first application to permit two computers to cooperate as peers instead of treating one as a terminal to the other (Hafner & Lyon, 1998). Telnet, FTP and TALK were the first applications to become available on ARPANET and

are still used in some form or another on the Internet today. TALK was the first program that allowed Netusers to engage in a real-time conversation over the network (Slevin, 2000). Netusers typed messages onto a split screen and read replies written at the bottom of the screen.

In early 1973, the network had grown to 35 nodes and was connected to 38 host computers (Rubinstein, 2009). That year, Norway and England were added to the network and traffic had expanded significantly. In 1974, Vint Cerf and Robert Kahn developed a set of protocols that implemented the open architecture philosophy.[23] These new protocols were the *Transmission Control Protocol* (TCP) and the *Internet Protocol* (IP). TCP includes rules that computers on a network use to establish and break connections; IP includes rules for routing of individual data packets. The Transmission Control Protocol/Internet Protocol (TCP/IP) organizes the data into packages, put them into the right order on arrival at their destination, and checked them for errors.

Most of the applications use the client/server model. A request is made for a particular service from the client to the server. The server responds or the conversation continues between the client and server until one of the participants ends it (Cerf & Kahn, 1974; Langford, 2000). By 1983, all networks connected to the ARPANET made use of TCP/IP and the old Network Control Protocol was replaced entirely. From then on, the collection of interconnected and publicly accessible networks using the TCP/IP protocols came to be called the "Internet" (Slevin, 2000).[24]

ARPANET grew into the Internet based on the idea that there would be multiple independent networks of rather arbitrary design (Leiner et al., 1997). The term "Internet" was first used by Vint Cerf and Robert Kahn in their 1974 article about the TCP protocol (Cerf & Kahn, 2000). The importance of the TCP/IP protocol in the history of the Internet is so great that many people consider Cerf to be the father of the Internet. A number of TCP/IP-based networks – independent of the ARPANET – were created in the late 1970s and early 1980s. The National Science Foundation (NSF) funded the Computer Science Network (CSNET) for educational and research institutions that did not have access to the ARPANET (Schneider & Evans, 2007).

Though the original design of the ARPANET was for resource sharing, it quickly demonstrated its utility as a message system. Soon researchers understood how useful the network can be for the transmission of communication. They continually sought to improve this characteristic of the network. In 1973, Lenny Kleinrock sent the first personal message over ARPANET; Ray Tomlinson of Bolt Beranek and Newman (BBN) wrote the first email program. The @ sign was introduced as a means of punctuating email addresses, separating the user name on the left from the site or computer identifier on the right.[25] Electronic mail grew first among the elite community of computer scientists on the ARPANET. They found it effective, convenient, easy to use and obviously much less time consuming than any other mode of communication. From its inception, email lacked formality and small-talk. It was a business tool to pass messages. Soon emailing bloomed across the Internet. While the ARPANET's creators did not have a grand vision for the invention of an earth-circling message-handling system, once the first couple of dozen nodes were installed, early Netusers turned the system of linked computers into a personal as well as a professional communications tool (Hafner & Lyon, 1998). Seventy five percent of the ARPANET traffic was email (Jenkins, 2001). ARPANET became a sophisticated email system.

On June 7, 1975, Steve Walker, a program manager at ARPA's Information Processing Techniques Office, announced the formation of an electronic discussion group which he called Message Services Group (MsgGroup) (Chick Net, n. d.). He sought to establish a group of people concerned with message processing in order to determine "1. What is mandatory; 2. What is nice; 3. What is not desirable in email functions" (Hauben, 1998). Walker wrote that his goal was not to establish another committee, but to see if dialogue can develop over the

Net. He was creating a prototype form to utilize computer conferencing to determine its capabilities (Hauben, 1998). This was an example of how the ARPANET and the Internet were developed: Setting up a prototype, inviting comments, checking feasibility, and developing the prototype further to accommodate needs.

In 1979, USENET, a "poor man's ARPANET," was created by Tom Truscott, Jim Ellis, and Steve Belovin to share information via email and message boards between Duke University and the University of North Carolina, using dial-up telephone lines and the protocols in the Berkeley UNIX distributions (Hauben & Hauben, 1997).[26] The original Usenet News Service was devoted to transmitting computing news and facilitating discussions among employees of university computing departments on topics such as operating systems and programming languages (Schneider & Evans, 2007). Later Usenet developed into a worldwide distributed discussion system. It consists of a set of newsgroups on specified subjects. "Articles" or messages are posted to the newsgroups and these articles are then broadcast to other interconnected computer systems via a wide variety of networks. The Usenet routes messages by topic, rather than by individual or through a mailing list. Any Netuser can post messages while others can view and reply to the posted messages. Some of the newsgroups are moderated for approval before appearing in the newsgroup. Others are not.[27]

The early 1980s saw the continued growth not only of the ARPANET but also of other networks. The Joint Academic Network (Janet, n. d.) was established in the United Kingdom to link universities there. It consists of a large number of sub-networks that connect between the UK's education and research organizations and between them and the rest of the world. In addition, Janet includes a separate network that is available to the community for experimental activities in network development.[28] In 1982, the ARPANET had 200 hosts and a year later the network grew to 500 hosts (Spinello, 2000).[29] In 1983, ARPANET, and all networks attached to it, officially adopted the TCP/IP networking protocol.[30] Mailing lists, information posting areas (such as the User's News Network, or Usenet, newsgroups), and adventure games were among the new applications appearing on the ARPANET (Schneider & Evans, 2007).

An important undertaking, very relevant for technoethics, took place in October of 1981, when a discussion group was formed on a computer message system at the Xerox Palo Alto Research Center. Recognizing that computer professionals in other areas might share similar concerns, the group debated the merits of forming an organization dedicated to raising the awareness of the profession and the public with regard to the dangers inherent in the use of computers in critical systems. They wished to devise common principles to guide technological innovations and application to benefit society in an ethical and responsible fashion. In June 1982, the group adopted the name Computer Professionals for Social Responsibility - CPSR. Up until the mid 1980s, CPSR focused nearly all of its energy on the dangers posed by the massive increase in the use of computing technology in military applications. It became known for its fierce opposition to the Strategic Defense Initiative (SDI), which President Reagan announced in early 1983.[31]

In 1983, a mere 500 computer hosts were connected to the Internet. In 1984, the number of hosts increased to 1024.[32] As more researchers connected their computers and computer networks to the ARPANET, interest in the network grew in the academic community. One reason for increased interest in the project was its adherence to an open architecture philosophy: Each network could continue using its own protocols and data-transmission methods internally. There was no need for special accommodations to be connected to the Internet, there was no global control over the network, and all could join in. This open architecture philosophy was revolutionary at the time. Most companies used to make their networks distinct and incompatible with other networks. They feared competition and strove to make their products inaccessible

to competitors. The shift to an open architecture approach is one of the most celebrated features of the Internet.

ENTERING THE COMMERCIAL PHASE

During the mid-1980s, the Internet entered its commercial phase. In 1984, the Department of Defense split the ARPANET into two specialized networks: ARPANET would continue its advanced research activities, and MILNET (for Military Network) would be reserved for military uses that required greater security. Connections were developed so that users could communicate between the two networks. In 1986, the number of Internet hosts increased to 5000. By 1987, when the number of hosts reached 10,000, congestion on the ARPANET caused by the limited-capacity leased telephone lines was becoming complicated. To trim down the traffic load on the ARPANET, a network run by the National Science Foundation, called NSFnet, merged with another NSF network, called CSNet, and with BITNET to compose one network that could carry much of the network traffic. As the civilian network became increasingly commercial, budget limitations impelled the U.S. government's departure from participation in the Internet's structure. In turn, private telecoms companies entered the picture (Cerf, 2008; Langford, 2000). The civilian network's use widened as a consequence of the proliferation of computer networks, and became more varied. Grassroots networks were established by university students. Merit Network, Inc., IBM, Sprint, and the State of Michigan were contracted to upgrade and operate the main NSFnet backbone.[33] By the late 1980s, many other TCP/IP networks had merged or established interconnections (Schneider and Evans, 2007).

In 1988, the NSFnet backbone was upgraded to DS-1 (1.544 Mbps) links, which was able to handle more than 75 million packets a day. This innovation immediately yielded further expansion of the Internet. The number of Internet hosts broke to 100,000.[34] The NSFnet began to encompass many other lower-level networks such as those developed by academic institutions. Gradually, the Internet as we know it today, a maze of interconnected networks came about (Spinello, 2000). Canada (CA), Denmark (DK), France (FR), Iceland (IS), Norway (NO) and Sweden (SE) connected to NSFnet.[35] The first transatlantic fiber-optic cable was installed, using glass fibers so transparent that repeaters (to regenerate and recondition the signal) were needed about 40 miles apart. Linking North America and France, the 3,148-mile shark-proof cable was capable of handling 40,000 telephone calls simultaneously.[36] The same year, Jarkko Oikarinen wrote a communications program that extended the capabilities of the Talk program for his employer, the University of Oulu in Finland. He called his multiuser program *Internet Relay Chat (IRC)*. By 1991, IRC was running on more than 100 servers globally. IRC's popularity grew among scientists and academicians for conducting open discussions about theories, experiments and innovation (Schneider & Evans, 2007).

In 1989, number of hosts reached 159,000.[37] Australia (AU), Germany (DE), Israel (IL), Italy (IT), Japan (JP), Mexico (MX), Netherlands (NL), New Zealand (NZ), Puerto Rico (PR), and the United Kingdom (UK) connected to NSFnet.[38] William Wulf proposed the idea of a *collaboratory* which argued for the creation of tools to allow linked computers to be used as a rich environment for computer-based collaboration. The term merged "collaboration" and "laboratory" to describe a "center without walls, in which the nation's researchers can perform their research without regard to geographical location--interacting with colleagues, accessing instrumentation, sharing data and computational resources, and accessing information in digital libraries" (Kouzes, Myers, & Wulf, 1996).[39] This idea was certainly apt for the evolving technology, in line with the *raison d'être* that drove the founding architects of the Net and one that continues to prevail throughout the history of the Internet to date.

Also in 1989, Englishman Tim Berners-Lee, a researcher at the Organisation Europeenne pour la Recherche Nucleaire (CERN) in Geneva, proposed the idea of an international system of protocols: Building a distributed hypermedia server which would allow Netusers to prepare electronic documents that are composites of, or pointers to, many different files of potentially different types, scattered across the world. Berners-Lee called it the World Wide Web (WWW). He wrote the first WWW client (a browser-editor running under NeXTStep) and most of the communications software, defining URLs (Uniform Resource Locator, webpage address), HTTP (Hypertext Transfer Protocol between a server and clients) and HTML (interactive HyperText Markup Language).[40] His hypermedia software program enabled people to access, link and create communications in a single global web of information. The web was superimposed on the Internet and incorporated its protocols. The web thus marked the coming together of three different strands of innovation: Personal computing, networking, and connective software (Curran & Seaton, 2009).[41] Using hyperlinks embedded in hypertext, Netusers acting as producers of information link up files containing text, sound and graphics to create webpages. The sources of information linked in this way can be located on any computer that is also part of the web. Each information source may itself be linked to an indefinite number of webpages. Hypertext and hyperlinks allow Netusers acting as receivers of information to wander from one source of information to another effortlessly, deciding for themselves which information they wish to have transferred to their browser and which link they want to explore or to skip (Slevin, 2000).[42] Netusers could also index the data they possess and search for further data.

THE MASSIVE EXPANSION

By the late 1980s, a significant number of people (mostly professionals) were using email but the Internet was not in the public eye. I was a student at Oxford University at that time and can testify that using the Internet was a most frustrating experience. Most websites were not accessible. Navigating between sites was anything but seamless. It was easier to retrieve information from the library in the good, old-fashioned way.

But things were soon about to change. During the 1990s we witnessed a massive expansion of the Net. The Internet's accessibility, its multi-application and its decentralized nature were instrumental in this rapid growth. Business as well personal computers with different operating systems could join the universal network. The Internet became a global phenomenon, more countries and people joined and groundbreaking minds expanded the horizons of the platform with new, imaginative innovations. In 1990, the ARPANET project was officially over when it handed over control of the public Internet backbone to the National Science Foundation (Curran & Seaton, 2009; Slevin, 2000). In 1991, the Internet Society was formed and Croatia (HR), Hong Kong (HK), Hungary (HU), Poland (PL), Portugal (PT), Singapore (SG), South Africa (ZA), Taiwan (TW) and Tunisia (TN) joined the NSFnet network whose backbone was upgraded to DS-3 (44.736 Mbps) as the traffic passed to 1 trillion bytes and 10 billion packets per month. That year, 1991, saw another milestone as the popular encryption program PGP (Pretty Good Privacy) was released by Philip Zimmerman (1996).[43] Unfortunately, PGP presents a technological-ethical challenge with significant social implications as it is also used by Net abusers. As PGP is freely available, powerful tool, it is used by criminals and radicals who wish to hide their Net identity in order to advance anti-social behavior. In other words, encryption is a double-sword crypto-assisted anonymity tool: It may enhance your privacy and anonymity but it might also undermine your own security.

In ethical terms, there is a conflict between anonymity, on the one hand, and trust and accountability on the other hand. Indeed, anonymity undermines accountability on the Internet: If Netusers can hide their identity and

be entirely sure that no one knows they are the agent of mischief, this might be an incentive for some people to adopt norms and codes of behavior that they would otherwise be deterred to adopt.[44] The Internet opened new horizons for criminals and terrorists.

In 1992, the number of Internet hosts broke to 1 million with almost 50 web pages.[45] In 1993, there were 623 Websites in the world.[46] The United Nations came on-line and the NSFnet expanded internationally as Bulgaria (BG), Costa Rica (CR), Egypt (EG), Fiji (FJ), Ghana (GH), Guam (GU), Indonesia (ID), Kazakhstan (KZ), Kenya (KE), Liechtenstein (LI), Peru (PE), Romania (RO), Russian Federation (RU), Turkey (TR), Ukraine (UA), UAE (AE), and US Virgin Islands (VI) joined the network. The World Wide Web proliferated at a 341,634% annual growth rate of service traffic.[47] By the end of 1993, there were 2.1 million hosts.[48] The phenomenal growth and success of the Internet were the result of technological creativity, flexibility and decentralization as well as healthy curiosity of people who wanted to be part of the scene.

In 1994, Cerf argued (1995) that the "Internet has gone from near-invisibility to near-ubiquity." The growth of the Internet, its expanding international character, and awareness to its effective features brought more and more business to believe in the innovation and to invest in it. Shopping malls arrived on the Internet. First Virtual, the first cyberbank, opened up for business. Two Stanford PhD students, Jerry Yang and David Filo, started out a website which they called "Jerry and David's Guide to the World Wide Web." This guide swiftly expanded and later changed its name to one word, Yahoo![49] More countries joined the network, including Algeria (DZ), Armenia (AM), Bermuda (BM), Burkina Faso (BF), China (CN), Colombia (CO), Jamaica (JM), Jordan (JO), Lebanon (LB), Lithuania (LT), Macao (MO), Morocco (MA), New Caledonia (NC), Nicaragua (NI), Niger (NE), Panama (PA), Philippines (PH), Senegal (SN), Sri Lanka (LK), Swaziland (SZ), Uruguay (UY), and Uzbekistan (UZ). The number of Internet hosts increased to 3 million. This necessitated technological accommodation and, indeed, the same year, the NSFnet backbone was upgraded to OC-3 (155mbps) links and the volume of traffic increased to 10 trillion bytes per month. To navigate between the growing numbers of sites, the first version of the popular Netscape web browser was released by Mosaic Communications Corporation.[50] Mosaic made using the Internet as easy as pointing a mouse and clicking on icons and words (Hafner & Lyon, 1998). By then, the birth pangs of the global network were over and information retrieval became efficient and effective.

In 1995, major carriers such as British Telecom, France Telecom, Deutsche Telekom, Swedish Telecom, Norwegian Telecom, and Finnish Telecom, among many others, announced Internet services. An estimated 300 service providers were in operation, ranging from very small resellers to large telecom carriers. More than 30,000 websites were in operation and the number was doubling every two months (Cerf, 1995). The growing importance of commercial traffic and commercial networks was discussed at a series of conferences initiated by the National Science Foundation on the commercialization and privatization of the Internet. The NSF first awarded a contract to Merit Network, Inc., in partnership with IBM and MCI Communication Corp., to manage and modernize the Internet backbone. Then the NSF awarded three additional contracts: One to Network Solutions, allowing them to assign Internet addresses; second to AT&T to maintain Internet directory and database services; third to General Atomics to maintain the provision of information services to Netusers. In 1995, the NSFnet was shut down completely and the American core Internet backbone was privatized (Curran & Seaton, 2009).

The result was that the number of hosts more than doubled in one year, reaching 6.6 million.[51] The mid-1990s were the years when the Internet established itself as the focal point for communication, information and business. A number of Net related companies went public, with Netscape leading the pack with the 3rd

largest ever NASDAQ IPO share value.[52] At the same time, many people began creating their own personal Web areas. Homepages and bookmarks were introduced to allow Netusers (about 16 million)[53] to organize their personal documents and to keep track of useful information. The Internet was growing strong in a rapid pace, attracting more and more people who grew to use it for their daily life: Finding information, research, business, commerce, entertainment, travel and essentially any need. For each and every need there came the entrepreneur who seized the opportunity and opened a website addressing the need.

In 1996, the number of Netusers more than doubled, from 16 million in 1995 to 36 million.[54] From the mid-1990s, the development of the Internet took a new turn as a growing number of large and medium-sized organizations started running the TCP/IP protocols on their internal organizational communication networks, called "intranets." For security purposes, intranets shielded themselves from the outside world by firewalls. These protection systems often allow for the exchange of information with the Internet via specified "gateways". These private networks are called "extranets" and allow organizations to exchange data with each other. By 1997, the market for intranets and extranets was growing annually at a rate of 40 per cent worldwide (Slevin, 2000). The number of Netusers estimated to be 70 million by the end of the year.[55]

At that time, the number of hosts was about 10 million with an untold number of links between them.[56] Finding information on the web became, yet again, a tricky issue but for different reasons. Connectivity was no longer the issue; rather, navigating and finding the information you needed in the growing maze was difficult. Addressing this challenge, two Stanford graduate students, Larry Page and Sergey Brin, started to work on a search engine which they called BackRub, as it was designed to analyze a 'back link' on the Web. Later they renamed their search engine Google, after googol, the term for the numeral 1 followed by 100 zeroes. They released the first version of Google on the Stanford Website in August 1996 (Battelle, 2005).[57]

In 1997, the Fiber Optic Link Around the Globe (FLAG) became the longest single-cable network in the world, providing infrastructure for the next generation of Internet applications. The 17,500-mile cable began in England and ran through the Strait of Gibraltar to Palermo, Sicily, before crossing the Mediterranean to Egypt. It then went overland to the FLAG operations center in Dubai, United Arab Emirates, crossing to the Indian Ocean, Bay of Bengal, and Andaman Sea; through Thailand; and across the South China Sea to Hong Kong and Japan.[58] With this infrastructure, that year alone some fifty additional country domains were registered. The Internet became truly international and the number of Internet hosts broke to 16 million.[59] The number of host computers grew to more than 36.7 million in mid-1998 while the number of websites had grown to 1.3 million. The number of sites was doubling every few months (Jenkins, 2001).

By 1998, there were approximately 150 million Netusers in more than 60 countries, representing about 2.5 percent of the world's population. The vast majority, or 130 million of those users, was located in the 15 most industrialized countries. Thus, despite its dramatic growth, large disparities in Internet access and usage persisted. A more accurate examination of the late-90's Internet usage reveals a user rate of 6.5 percent in a small number of high-usage nations and only a 0.5 percent usage rate in the remaining 200 countries (Langford, 2000; Spinello, 2000; Paré, 2005). There were clear differences between developed and developing countries. There still are.

The same year, 1998, the Internet Corporation for Assigned Names and Numbers (ICANN, 2010) was established. It is a not-for-profit public-benefit corporation with participants from across the world dedicated to keeping the Internet secure, stable and interoperable. ICANN promotes competition and develops policy on the Internet's unique identifiers. It does not control Internet content, cannot stop spam, and it does not deal with access to the global

network. But through its coordination role of the Internet's naming system, it does have an important impact on the expansion and evolution of the Internet.[60] ICANN has secured long-term commitments of funding from registries and registrars to support its Internet-coordination activities, including the performance of the IANA functions which came under its control.

Large corporations became more aware of the massive potential of the Internet. America Online (AOL), Microsoft, Sun Microsystems, Inktomi, Yahoo! and Cisco caught the attention of Wall Street valuations. AOL alone had seen its stock rise 50,000 percent (McCracken, 2010). In 1998, AOL acquired Netscape Communications Corporation for a stock transaction valued at $4.2 billion. Microsoft bought Hotmail for $400 million. In 1999, online retailers reported 5.3 billion sale.[61]

By December 1999, the total number of Netusers worldwide was estimated to be 248 million.[62] For the fourth year running, the number of Netusers was growing in an extraordinary pace, doubling from one year to another. The United States, Western Europe and affluent parts of Asia produced much of the content of the web, while the rest of the world continued to contribute very little (Curran and Seaton, 2009). In 2000, the USA produced almost two-thirds of the top thousand most visited websites. It accounted for 83% of the total pageviews of Netusers. Less than 10% of the world speaks English as their first language, but English was becoming intelligible to a growing number of people, and has begun to assume the function once occupied by Latin in medieval Europe. In the late 1990, an estimated 85% of the web was written in English (Curran & Seaton, 2009). This picture, however, was rapidly changing.

In 2000, there were 361 million Netusers and the ten millionth domain name was registered.[63] The number of websites exceeded 50 million with a growing number of Internet Service Providers (ISPs) (Jenkins, 2001). BBC News Online (Postel, 1998) reported that 50 percent of the U.S. population had home Internet access. In Europe as a whole (despite high distribution in Scandinavia, Britain, and elsewhere) the proportion was as low as 4 percent, and only 3 percent in Russia. In China the figure was not much above 1 percent, and in Africa it was 0.016 percent (Schuler & Day, 2004). Subsequently, these figures have grown, in some cases dramatically, but large disparities still exist.

Not only legitimate businesses realized the potential of the Internet. Criminals were also quick to abuse the Internet for profit. On June 22, 2001, the European Council finalized its international *Convention on Cybercrime* and adopted it on November 9, 2001.[64] This was the first treaty addressing criminal offenses committed over the Internet. The same year, Firewall Enhancement Protocol (FEP) was proposed, and Jimmy Wales and Larry Sanger launched "Wikipedia," the web based free encyclopedia. It is a collaborative, multilingual project supported by the non-profit Wikimedia Foundation. Its 17 million articles (over 3.3 million in English) have been written by volunteers around the world, and almost all of its articles can be edited by anyone with access to the site.[65] Wikipedia became the largest and most popular general reference resource on the Internet.

The same year, 2001, there were 513 million Netusers and English ceased to be the language of the majority of users. English fell to a 45 percent share (Kleinrock, 2008). The following year, broadband Netusers exceeded the number of dial-up users in the United States (Kleinrock, 2008). This had massive implications. With more broadband, gigantic storage capacities, wireless access, and advanced visual displays the technology facilitated peer-to-peer file sharing networks, photo and video generation and sharing, and the construction of social networking mechanisms where people can report and upload any data they may wish to share.

SOCIAL NETWORKING

The study of Internet social networking is of much need in the field of technoethics. Most people use social networks to socialize, exchange information and ideas; some, however, abuse

social networks to advance anti-social, violent purposes like terrorism and child pornography. In July 2003 Myspace was founded by Tom Anderson and Chris DeWolfe. MySpace allows members to create unique personal profiles online in order to find and communicate with old and new friends. The services offered by MySpace include any MySpace branded URL (the "MySpace Website"), the MySpace instant messaging service, the MySpace application developer service and other features.[66] MySpace became the most popular social networking site in the United States. In June 2006, there were more than 100 million MySpace users. It is estimated that every month over ten million American teens log on to MySpace. However, in 2008 Myspace was overtaken internationally by its main competitor, Facebook.[67] Facebook.com was founded on February 4, 2004 by Mark Zuckerberg, Eduardo Saverin, Dustin Moskovitz and Chris Hughes (Carlson, 2010). Facebook started as a social network for American universities but in September 2006 the network was extended beyond educational institutions to anyone with a registered email address. The site remains free to join, and makes a profit through advertising revenue.

In addition to the abovementioned features, as of 2007, Facebook users can give gifts to friends, post free classified advertisements and even develop their own applications - graffiti and Scrabble are particularly popular (Phillips, 2007). On July 22, 2010, the 500 millionth signed account on the largest social network (22 percent of all Netusers). Facebook users spend more than 500 billion minutes a month on the site, share more than 25 billion pieces of content each month (including news stories, blog posts and photos), and each of them, on average, creates 70 pieces of content a month (Rosen, 2010; Arthur & Kiss, 2010).[68] Three years after the founding of Facebook, in 2007, Microsoft made $15bn bid to buy the company but Zuckerberg declined (Lowensohn, 2010). He did not want to lose control over his creation. In 2010, Facebook is estimated to worth $52.1 billion.[69]

In 2005, there were 1,018 million Netusers.[70] That year, three former employees of Paypal, Chad Hurley, Steve Chen and Jawed Karim created a video file sharing website called "YouTube." The official debut was December 15, 2005. On October 9, 2006, Google bought YouTube for $1.65 billion (Lidsky, 2010).

The same year, in 2006, the free social networking site Twitter was started by Jack Dorsey. Essentially, Twitter combines Short Code Messaging, SMS with a way to create social groups. One can send information to one's followers and receive information from individuals or organizations one has chosen to follow (Malik, 2009).[71] There are more than 100 million registered Twitter users (Rosen, 2010).

The number of Netusers continued to grow from 1,319 million in 2007, to 1,574 million in 2008, to 1,802 million in 2009, to 1,971 million in September 2010.[72] The most recent figure accounts for some 29% of the world population. As of December 2010, the Indexed Web contains at least 2.69 billion pages.[73] Table 1 shows the world Internet usage statistics and population statistics.

CONCLUSION

The Internet and its architecture have grown in evolutionary fashion from modest beginnings, rather than from a Grand Plan (Carpenter, 1996). The ingenuity of the Internet as it was developed in the 1960s by the ARPA scientists lies in the packet switching technology. Until ARPANET was built, most communications experts claimed that packet switching would never work (Roberts, 1999).[75] In 1965, when the first network experiment took place, and for the first time packets were used to communicate between computers, the scientists did not imagine the multiple usages of this technology on society. Kleinrock, the inventor of packet switching, explicitly wrote that he did not foresee the powerful community side of the Internet and its impact on every aspect of society (Kleinrock, 2008). The Net diffusiveness and its focus on flexibility, decentralization and

Table 1. Internet usage statistics74 world internet users and population stats

World Regions	Population (2010)	Internet Users Latest Data	Penetration (% Population)
Africa	1,013,779,050	**110,931,700**	10.9%
Asia	3,834,792,852	**825,094,396**	21.5%
Europe	813,319,511	**475,069,448**	58.4%
Middle East	212,336,924	**63,240,946**	29.8%
North America	344,124,450	**266,224,500**	77.4%
Latin America/Caribbean	592,556,972	**204,689,836**	34.5%
Oceania / Australia	34,700,201	**21,263,990**	61.3%
WORLD TOTAL	6,845,609,960	**1,966,514,816**	**28.7%**

collaboration brought about the Internet as we know it today. In the initial stages, the Internet was promoted and funded, but not designed, by the U.S. government. Allowing the original research and education network to evolve freely and openly without any restrictions, selecting TCP/IP for the NSFnet and other backbone networks, and subsequently privatizing the NSFNET backbone, were the most critical decisions for the Internet's evolution.

The Internet's design was unprecedented because it was conceived as a decentralized, open and neutral network of networks. The open architecture of the Internet allows free access to protocols from anywhere in the world and is capable to accept almost any kind of computer or network to join in. The choice of any individual network technology is not dictated by particular network architecture but rather could be selected freely by a provider and made to interwork with other networks through a meta-level "Internetworking Architecture."[76] This open architecture encourages the development of more net applications. And the Internet is neutral between different applications of text, audio and video. This allowed new and better applications (like email, the World Wide Web, and peer-to-peer technology) to evolve and replace the old (Goldsmith and Wu, 2006).

There are inherent tensions between the various technological tools: Those designed to enhance one's privacy may harm security and *vice versa*. They can be put for good use (filtering child pornography) and might cause abuse (encrypting child porn images). Encryption promotes privacy and anonymity on the Net but, at the same time, anonymity does not contribute to cultivating a sense of Net responsibility or trust.

At the beginning of the 21st Century, the Internet embraces some 300,000 networks stretching across the planet. Its communications travel on optical fibers, cable television lines, and radio waves as well as telephone lines. The traffic continues to grow in a rapid pace. Mobile phones and other communication devices are joining computers in the vast network. Some data are now being tagged in ways that allow websites to interact.[77] Today, the growth of cloud computing is providing powerful new ways to easily build and support new software. Because companies and individuals can "rent" computing power and storage from services like the Amazon Elastic Compute Cloud, it is much easier and faster for someone with a good idea to turn it into an online service. This is leading to an explosion in new uses for the Internet and a corresponding explosion in the amount

of traffic flowing across the Internet (Nelson, 2010). The result is the most impressive web of communications in the history of humanity. Millions of people around the globe cannot describe their lives and function as they wish without the Internet.

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ENDNOTES

1 During its lifetime, this agency has used two acronyms, ARPA and DAPRA, Defense Advanced Research Projects Agency.

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5 Leonard Kleinrock, personal communication (July 19, 2010).

6 David D. Clark, personal communication (July 19, 2010). See also Kleinrock (August 2010: 26-36).

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14 See also Gillies and Cailliau (2000).

15 Steve Crocker from UCLA played a key role in establishing the request for comments in 1969. See http://tools.ietf.org/html/rfc1

16 See also Salus (1995).

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18 See also Danny Cohen, Remembering Jonathan B. Postel, http://www.postel.org/remembrances/cohen-story.html

19 "'God of the Internet' is dead" (October 19, 1998).

20 UNIX Introduction, http://www.ee.surrey.ac.uk/Teaching/Unix/unixintro.html

21 'Host' means computer that is connected to the network.

22 Recap the Internet history, at http://www.broadbandsuppliers.co.uk/uk-isp/recap-the-history-of-Internet/

23 The idea was originally introduced by Kahn in 1972 as part of the packet radio program.

24 See also White (2006: 13) and generally Abbate (2000).

25 http://www.bbn.com/about/timeline/; *pioneers of the net*, http://www.chick.net/wizards/pioneers.html . The first head of the state to send an email message, in 1976, was the Queen of England, Elizabeth II. See Recap the Internet history, at http://www.broadbandsuppliers.co.uk/uk-isp/recap-the-history-of-Internet/

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[53] INTERNET GROWTH STATISTICS, http://www.Internetworldstats.com/emarketing.htm

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[75] Roberts wrote: "Packet switching was new and radical in the 1960's. In order to plan to spend millions of dollars and stake my reputation,

I needed to understand that it would work. Without Kleinrock's work of Networks and Queuing Theory, I could never have taken such a radical step. All the communications community argued that it couldn't work. This book was critical to my standing up to them and betting that it would work." Quoted in Gillies and Cailliau (2000: 26).

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