Heterogeneous Engineers of the Internet. How Inventors Weaved Together Internet Technologies, Social Values and Blueprints for New Social Institutions.

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SUMMARY: The paper is an investigation into the prehistory and history of the Internet technologies. These are considered as the core of a wider sociotechnical system and their creators are seen as engineers, who in their work address social issues as well. Initially, a theoretical model is provided for understanding the social aspects of technologies and for describing inventors as social engineers as well, drawing on concepts of Thomas Hughes and Bruno Latour. Afterward the development of time-sharing computing, of computer networks and specifically the ARPANET network, introduction of the TCP/IP protocol and creation of the World Wide Web are presented, with an emphasis placed on social aspects of these technologies. Finally, an analysis of the social visions and values tied to the creation of Internet technologies is offered. Augmentation of individual and collective management of ever more complex information was of primary importance for Internet's creators. In this manner, their visions are similar to those offered by theorists of information society and fail to address later developments of the Internet, tied to its extremely fast growth and diffusion in the 1990s.

Introduction

Internet, like any other technology, can be considered a sociotechnical system, whose development is influenced by social and cultural factors. Manuel Castells divides creators of the Internet into four groups: techno-elites, hackers[1], virtual communitarians and entrepreneurs, each with a specific culture that influenced what he calls the culture of the Internet (Castells 2001). Characteristically, members of these groups were all both constructors and users of respective technologies.

This paper concerns the earliest of the creators, inventors of key Internet

1 It is important to note, as always is done, but seemingly never enough, that by hackers we understand not malicious programmers, but "a person who enjoys exploring the details of programmable systems and how to stretch their capabilities, […] One who programs enthusiastically (even obsessively) […] A person who is good at programming quickly" (Hacker Jargon File)

technologies[2] and looks into values that they embraced and social issues they addressed. The analysis is limited to the first two cultures mentioned by Castells and focuses upon a narrow group of inventors of key hardware and software components. The focus on individuals is deliberate and justified not only by the fact that their views can be seen as representative of the wider milieus. While not neglecting wider social, economic and political processes, we agree with Castells that development of the Internet is largely due to the capacity of "gentlemen of technological innovation" (Castells 2001, 33)to "transcend institutional goals and bureaucratic barriers" (Castells 2001, 9). We are less interested in the technical specifications and rather in what can be called blueprints for technologically augmented institutions of today, which the inventors created. Social projects and visions developed alongside technological innovations are analyzed and an attempt is made to single out values that guided these efforts. Kluckhohn's classical definition of a value as a "conception, explicit or implicit, distinctive of an individual or characteristic of a group, of the desirable which influences the selection from available modes, means and ends of action" (Kluckhohn, quoted in Ziółkowski 2002, 292) is here useful. In the case of Internet's history, we consider values as factors influencing the shaping of a technology.

The history presented here is far from being complete. If we draw the line between Internet's history and present at the point in 1990s of Internet's rapid diffusion, then missing here is an account of the development of alternative, or even countercultural networks like USENET or BITNET; of the free or open source programming movement; and of the development of interfaces and applications, whose characteristics prominently shape our experience of using the Internet and our perceptions of the online social space. We focus on the creators of two basic technologies lying at the heart of the Internet: the telecommunication network and the single information space. In their development, we track two major goals of the techno-elite: the augmentation of individuals and facilitation of collaborative work, both pursued in face of an increasingly complex reality.

New Princes of Sociotechnical Systems

Thomas Hughes proposes to write history of technologies as if they were not only material artifacts within a separate technical sphere, but sociotechnical systems. Instead of what he calls an internalist approach, reductionist and technologically deterministic, Hughes speaks about complex systems in which the

2 Historians of the Internet agree in tracing the trajectory of the Internet back to the ARPANET, earlier computer networking efforts and finally time-sharing computers. By Internet technologies I understand the whole range of technologies at the cores of both the Internet and earlier computer networks.

technical and the social interact. The sociotechnical system is seamless, and its artifacts “should be seen as a function of the interaction of heterogeneous elements as these are shaped and assimilated into network” (Law 1987, 113). Among them are social, economic or political forces “indissolubly linked with the technological” (Law 1987). By social, Hughes understands the world that is not technical, made up of institutions, values, interest groups, social classes, political and economical forces (Hughes 1994). The social is not seen as “standing behind the system being built and exercising special influence” (Law 1987) or even as a a privileged element of the system.

Builders of a sociotechnical system weave “a seamless web of technology and institutional change” (Hughes 1991, 14). These are engineers, managers or financiers and often a system builder combines several of these functions. As an example, Hughes in his study of Elmer Sperry, inventor of the gyrocompass, Hughes shows that he invented not only the device, but institutions for its manufacturing and marketing. John Law calls this “heterogeneous engineering” (Law 1987).

We will consider the Internet as an example of what Hughes calls a large-scale sociotechnical system. The core of this system is formed by the Internet understood strictly as a technology – in accordance with the definition of the Internet provided by the American Federal Networking Council, which considers the Internet to be a global information system of all computers connected by the TCP/IP protocol and providing services on top of the protocol (FNC 1995). The Internet as a sociotechnical system, together with the users and their values, sociotechnical institutions, content and the virtual social space, exists around this technological core.

Successful large-scale engineering is difficult and the shape of engineered artifacts – in this case of a telecommunication network - is a function of the interaction of heterogeneous elements (Law 1987, 114). The creators have a privileged, autonomous position in any system, but need to weave a complex web of heterogeneous elements. Hughes introduces the concept of technological momentum, an impetus that develops during the life cycle of a sociotechnical system that both shapes and is shaped by the society. This interaction is asymmetrical over time. Initially, in the phases of invention and development, the inventors are a focal point of the system and technology is clearly socially constructed. By embodying economic, social and political characteristics in a technology, inventors provide it with “needs for survival in the use world” (Hughes 1987, 62). As a technology matures, knowledge, material artifacts and human actors are drawn into, aligned with its system. The acquired momentum provides the system with durability and propensity for growth, allowing it to become the shaper of its environment (Hughes 1994, 111). Hughes observes that high momentum of a system can give the impression of technology's autonomy (Hughes 1987, 79).

Purposeful changes in a sociotechnical system lead to unintended malfunctions in other components and until equilibrium is reached, there is opportunity for invention (Hughes 1991, 13). We are concerned with the early phases of Internet's life cycle, when it was a technology developed by a small community of engineers and scientists funded by an American research agency placed inside the military-industrial complex. During this period, the inventors were to a large extent guided by own goals, were catering to the needs of a small group of users and the incentive for invention came mainly from technological challenges. This period lasted until early 1990s, when Internet became stable and usable enough to draw attention of mass users and commercial players. But, as Bruno Latour observes, "the project never stops from being a front line, even when it seems that everything has been done and that 'mere consumers' are now to be convinced" (Latour 1998). In the 1990s, a radical change took place, which can be seen as another unintended malfunction of the system – dramatic growth of user population and new needs of the mass consumer have again thrown the system out of equilibrium. Today, innovation is partially fueled by original motives of the techno-elite and hacker cultures, but also by the need to respond to customized and changing customer needs (Neff and Stark 2002, 3). Bruno Latour writes that consumers are "unreliable and feckless […], always shifting from opinion to another, enslaved by fashion and passion. To keep them well aligned, one needs constantly renewed and fresher resources" (Latour 1998).

Inventors of Internet technologies fit the description of New Princes presented by Bruno Latour in a text "How to Write the 'Prince' for Machines As Well As Machinations" (Latour 1998). In a society, in which the shaping of social institutions by telecommunication technologies can be considered its key characteristic (Castells 2001), the potential to shape sociotechnical systems becomes a new form of power. Latour expands Machiavelli's "The Prince", "so as to describe at once machines and machinations" (Latour 1998) – out of concern for "technical democracy", existence of a democratic public sphere in conditions of a technological society. Latour writes: "If science and techniques are politics pursued by other means, then the only way to pursue democracy is to get inside science and techniques, that is, to penetrate where society and science are simultaneously defined through the same stratagems. This is where the new Princes stand" (Latour 1998). The new Princes are able to simultaneously appeal both to humans and non-human allies, to use "the obstinacy, the cunning, the strength of electrons, microbes, atoms, computers, missiles" (Latour 1998).

Institutional engineering: creation of ARPA and IPTO

The first step towards creating the Internet was an act of institutional, and not technological, engineering. A space was created in which inventors were granted a high degree of freedom to work on their inventions. Initially the Office of Scientific Research and Development (OSRD) was created in the United States during World War II to provide scientific support to the war effort. Vannevar Bush, a scientist and head of the OSRD, prepared in 1945 a report titled “Science: The Endless Frontier”, in which he stated that if scientific research is to serve postwar American society, basic research is necessary. Bush believed the government has authority to support it as part of providing general social welfare. Such research, according to Bush, must be “free - free from the influence of pressure groups, free from the necessity of producing immediate practical results, free from dictation by any central board” (Hauben 2000b). An agency was needed to freely conduct “research that in general is directed toward new concepts, new principles, rather than producing a piece of hardware” (Hauben 2000b). In 1958, in response to the launch of the Sputnik by Russians, the Advanced Research Projects Agency (ARPA) was created. ARPA was situated inside the Department of Defense, protecting it from pressures from industrial interests. As Bush wrote “industry is generally inhibited by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity” (Hauben 2000b). The Agency received large governmental funding but despite this remained highly independent and shielded from internal pressures as well. Having also the ability to fund academic research projects, it became -according to Howard Rheingold - “one institution capable of sponsoring the creation of an entire new technology” (Rheingold 2000).

History of the Internet is commonly described as an appropriation of a military technology by the society: initially by scientists and researchers, then countercultural movements and finally the mass user. In fact, computer technologies developed by ARPA and specifically by its Information Processing Techniques Office (IPTO) were funded by the military and eventually used by the military. But ARPA was set up to provide buffers between researchers and military officials, to secure the autonomy of the former and agency's directors used the rhetoric of military goals and pragmatic outcomes to obtain funding for basic research (Abbate 2000). At the most general level, military imperatives drove research (Cerf, quoted by Abbate 2000) and in that sense computers and the Internet are Cold War technologies. Early computers were created to conduct ballistic calculations and to be used in rocket guidance systems; and creation of ARPA is directly tied to the “space race”, being set up to rapidly advance defense-related technologies in response to the Sputnik launch (Rheingold 2000). At the same time, ARPA and IPTO managers secured freedom of research. Manuel Castells speaks in this context about the "capacity to transcend institutional goals, overcome bureaucratic barriers and subvert established values" (Castells 2001, 9). Researchers and programmers espoused such values as individual freedom, independence of thinking and free sharing and cooperation with peers, but limited to the narrow reality of their research. They did not form a countercultural milieu and "certainly did not see any problem in having their research funded by Pentagon […] in the midst of the Vietnam War" (Castells 2001, 24). Castells calls them "obsessed with their extraordinary technological adventure" and Howard Rheingold describes hackers working on first time-sharing computers at the Project MAC at MIT as "outcasts from the wider society, from their fellow techies, and even from most other computer scientists", who "happened to be the people who were creating the future of computing" (Rheingold 2000).

ARPA researchers were "in an ambiguous position between their accountability within the terms provided by those who employ them, and the premise that their value to their employer lies in the autonomous exercise of their professional skill" (Suchman 2000b). The researchers were in a state called by Suchman detached intimacy: "an elaborate social world within which one can be deeply engaged, but which remains largely self-referential, cut-off from others who might seriously challenge aspects of the community's practice" (Suchman 2000b). This detachment shielded researchers from pressures from the state administration, but also from any forms of democratic control or outside representations that could secure fulfillment of more general interests. It is this unaccountability of the new Princes and the ambiguity of their position that worries Latour.

Time-sharing computers and man-machine symbiosis

J.C.R Licklider was a psychologist with a degree of computer knowledge, exploring ways of applying electronics to spoken human communication. In 1957, Licklider conducted a personal time-use study of own scientific activities and discovered that 85% of his time is used up in preparations: finding, obtaining and sorting information. His conclusion was that a machine could perform such clerical or mechanical work more quickly and effectively. In 1960, Licklider published a paper titled "Man-Computer Symbiosis", which proposed an alternative to the earlier model of a "mechanically extended man", in which the human operator provided initiative and direction in man-machine systems. Licklider writes, that in such systems "There was only one kind of organism-man-and the rest was there only to help him" (Licklider 1960). The alternative solution was not for machines to replace humans in what could be called "humanly extended machines", but cooperation, pooling of heterogeneous but complementary resources in a symbiotic system, understood as "close union of two dissimilar organisms" (Licklider 1960).

Licklider considered computers able to formulate problems and think in "real time", while men in the meantime set goals and supply innovations. Man-machine interaction was a necessary step in transforming the computer from a calculator to a personal assistant. This was a revolutionary idea in a time when computers were solely used for data processing using a batch-processing method. A researcher provided data to computer's operator and received the results after more than a day. Licklider's vision coincided with research on a new form of computing, called time-sharing. In 1961, John McCarthy described how simultaneously several users could directly use a single computer, with computing power easily divided between them due to speed mismatch between the computer and humans. McCarthy proposed human-computer relationship as a key new research topic. The concept of time-sharing is interesting, because it provides a model solution for dealing with the speed mismatch between humans and computers, which can be seen as a significant sociotechnical problem.

Thinking along similar lines, Licklider envisioned a "thinking center", which would "incorporate the functions of present-day libraries together with anticipated advances in information storage and retrieval and the symbiotic functions suggested earlier in this paper. [...] In such a system, the speed of the computers would be balanced, and the cost of the gigantic memories and the sophisticated programs would be divided by the number of users" (Licklider 1960). In 1962, J.C.R. Licklider was invited to become head of the Information Processing Techniques Office (IPTO), responsible for research into this new form of computing. Licklider believed in "pertinence of interactive computing, not only to military command and control, but to the whole world of day-to-day business" (Licklider, quoted in Rheingold 2000) and turned out to be the ideal person for this position. This pooling of individual talent and vision with adequate institutional resources was, according to Rheingold, one of the moments marking the beginning of the age of personal computing.

Introduction of first time-sharing systems in the 1960s led to novel social consequences. Fernando Corbato and Robert Fano, time-sharing pioneers at the MIT, wrote in 1966: "The time-sharing computer system can unite a group of investigators in a cooperative search for the solution to a common problem, or it can serve as a community pool of knowledge and skill on which anyone can draw according to his needs. Projecting the concept on a large scale, one can conceive of such a facility as an extraordinarily powerful library serving an entire community in short, an intellectual public utility" (Hauben 1995).

In 1968, in a paper titled "The Computer as a Communication Device", J.C.R. Licklider and Robert Taylor predicted: “In a few years, men will be able to communicate more effectively through a machine than face to face” (Licklider and Taylor 1966). At that time, only as few as half a dozen such “interactive multi-access computer communities” existed (Licklider and Taylor 1966). They describe a community brought into existence by one of first instances of computer-mediated communication (CMC): a computer system that facilitates working together and sharing of intellectual resources. In the late 1960s, this was a radical idea (Rheingold 2000). Users of time-sharing systems were bonded by common interest in new computing systems, by sharing of programs and know-how and by collaborative work. Licklider and Taylor wished to augment group decision-making and problem solving by allowing, through CMC, for better externalization of individual mental models (Rheingold 2000). Overcoming geographical separation between time-sharing communities was the next logical step that would transform the separate communities into what Licklider and Taylor call a supercommunity. “It appears that the best and quickest way […] to move forward the development of interactive communities of geographically separated people - is to set up an experimental network of multi-access computers” (Licklider and Taylor 1966). They proposed to set up an initial interactive system, which would then be used to develop more interactive versions in an open-ended, evolutionary process. Licklider and Taylor drew a sharp distinction between the academic and commercial systems, with the former being more open-ended and fostering a stronger community.

Licklider’s and Taylor’s vision, being an extrapolation of experiences of an experimental community of about 1000 researchers, is not without its faults. The key one being, most probably, the almost sole focus on intellectual life of communities, centered around creative collective work and interactive modeling of problems. They mention following advantages of such communities: “First, life will be happier for the on-line individual because the people with whom one interacts most strongly will be selected more by commonality of interests and goals than by accidents of proximity. Second, communication will be more effective and productive, and therefore more enjoyable. […] And, fourth, there will be plenty of opportunity for everyone (who can afford a console) to find his calling, for the whole world of information, with all its fields and disciplines, will be open to him-with programs ready to guide him or to help him explore” (Licklider and Taylor 1966).

Licklider and Taylor believe in the possibility of expanding individual freedom and empowering communities through introduction of interactive time-sharing computing and later a supercommunity of interconnected networks. Still, they were concerned with equality of chances: “For the society, the impact will be good or bad, depending mainly on the question: Will “to be on line” be a privilege or a right? If only a favored segment of the population gets a chance to enjoy the advantage of “intelligence amplification,” the network may exaggerate the discontinuity in the spectrum of intellectual opportunity” (Licklider and Taylor 1966). They rightly observe that future equality depends not only upon institutional arrangements, but also upon responsiveness of human minds.

Finally, one more concept of J.C.R. Licklider needs to be introduced – that of the “Intergalactic network”, which Licklider described as “a single time-sharing system that was intergalactic”. It was a guiding vision, solving the issue of envisioning “what's possible and preferable to do next”, which becomes difficult when breakthroughs occur at rapid pace (Rheingold 2000). Intergalactic network was a vision of what was to be ultimately done. It seems that Licklider used the concept mostly for its social mobilizing effect, as he later stated: “I deliberately talked about the intergalactic network, but deliberately did not try to do anything about netting them [computers] together because it was becoming very difficult just to get them to run” (Hauben 2000b). This is a crucial vision, of an Internet that is incomplete as long as it is not ubiquitous.

To sum up a double shift in thinking about computers occured. Firstly, it became clear that computers can be used interactively, Secondly, a discovery was made that time-sharing leads to the formation of communities of users, tied by common resources and work. This second development came unplanned and unexpected, due to the fact that for economic reasons interactive computers were initially time-sharing machines.

ARPANET and early networking efforts

In 1967, Lawrence Roberts published an article called “Mutiple Computer Networks and Intercomputer Communication”, a design paper for ARPANET, an ARPA sponsored computer network that was Internet's predecessor and started running same year. The article lists several reasons for creating computer networks: load sharing, message service, data and program sharing, remote service. These allow to cut economic costs and improve research by sharing at a distance scarce computing resources. The last reason is scientific communication: “A network would foster the ‘community’ use of computers. Cooperative programming would be stimulated, and in particular fields or disciplines it will be possible to achieve a “critical mass” of talent by allowing geographically separated people to work effectively in interaction with a system” (Roberts 1967).

Creators of ARPANET made three crucial architectural decisions: to create a packet switching network, to make it a distributed one and to create and accept a single software network protocol. Packet switching had mainly technical consequences, as it allowed for more efficient and fair sharing of the communication channel. Since this was a scarce resource as well, packet sharing meant that computing would become more affordable (Abbate 2000). The concept of a distributed network assumed that it would function without central control, based only on a distributed, local routing policy. It would also lack a central node, with all nodes redundantly connected to each other. Research conducted in parallel by three different research centers suggested that a distributed network offered both more reliable and error-free digital communication as well as "better survivability […] in the cases of enemy attacks directed against nodes, links" (Baran 1964)[3]. Together, the first two concepts meant that the new computer network would not consist of separate circuits – communication channels – but become a single communication space.

Inventors of the ARPANET understood the need of ensuring some level of homogeneity between nodes characterized both by different computer hardware and software, but also different personal aspirations and research projects. Technical as well as social solutions to this problem were proposed. J.C.R. Licklider, in a 1963 memo written to members of what he called the Intergalactic Computer Network, addressed the issue of the diversity of computer systems and programs coexisting in the common network and proposed two solutions: to provide a certain level of transparency of individual actions and "to follow group consensus in the making of the arbitrary and nearly-arbitrary decisions that arise in the design and implementation of languages" (Licklider 1963). Group consensus will become an important decision-making mechanism, used until today by the Internet Engineering Task Force (IETF), a community responsible for the shape of Internet's technical architecture, uses it until today. As for technical solutions, Roberts writes in his ARPANET specification: "researchers have agreed to accept a single network protocol so that they may all participate in an experimental network" (Roberts 1967). Such protocol was to control origin, destination and routing of packets and to check for transmission errors, but not interfere with the data transmitted. The protocol would ensure that the single communication space would be common as well. In 1970 the Network Working Group (NWG) finished works on the initial ARPANET protocol called the Network Control Protocol (NCP).

Creation of the TCP/IP protocol and birth of the Internet

3 Interestingly, Baran felt that survivable communications might slow down the nuclear arms race. More survivable systems meant that "the country's retaliatory capability could better allow it to withstand an attack and still function; a more stable position" (Baran, quoted in Abbate 2000, 10).

ARPANET's creators believed that "greater human-to-human communication by means of increased technical inspiration among the different participants in the network" can be achieved (Kahn, quoted in Hauben 2000a). They anticipated that packet switched computer networks will rapidly grown and in the future support many forms of communication, including applications for government and private industry. Some were also conscious of the fact that private networks under utilize capabilities inherent in the design. Advance planning and control over the medium was becoming a crucial issue. Already then, unexpected effects began surfacing, proving that any amount of planning might as well be insufficient. As Robert E. Kahn observes, the ARPANET was originally designed as a network for strictly computer communications, but its capabilities have been quickly extended to include human communication and sharing of human resources (Hauben 2000c).

In 1972, the First International Conference on Computer Communications (ICCC) took place in the United States, during which ARPANET was for the first time publicly demonstrated to a group of 1000 engineers and researchers. The need for long-term planning of technological developments and forecasting of their consequences was a reoccurring theme in the presentations. Carl Hammer stated in a speech titled "Computer Communications: The Future" that long term planning is necessary to guide technical developments in socially beneficial direction and that governments must be made aware of complementing and competitive technologies and must learn to understand the practical, social, and economic impacts (Hammer, quoted in Hauben 2000c). In a similar tone, Herbert Maisel doubted whether government has sufficient knowledge to develop the new medium with public benefit in mind: "Unless the profit motive is supplemented by the public concern, the public may not benefit" (Maisel, quoted in Hauben 2000c).

Shared networks were considered a solution to the issues of securing public benefit of computer network usage and of inadequacies of private networks. Since connection of networks usually revealed fundamental incompatibilities, standards were seen as the mechanism that could make communication between networks possible. At that time, networks other than the ARPANET were being created, including a radio and a satellite network. Robert E. Kahn called this the "Multiple Network Problem" and believed that a solution could be reached through an appropriate software protocol. The NCP protocol used by ARPANET was insufficient, because it was unable to address computers outside this network and relied on ARPANET's hardware configuration. Kahn began working on what he called "Internetworking Architecture" in the form of a software protocol independent of the underlying technology and capable of connecting heterogeneous networks. Among ground rules worked out by Kahn, two are interesting to us:

distinct networks would need no internal changes in order to be able to connect and there would be no global control at the level of protocol. In 1973, Kahn together with Vinton G. Cerf created a protocol, which after a redesign was split into a suite of two complementary protocols called the Transmission Control Protocol / Internet Protocol (TCP / IP). Scott Bradner, an expert on Internet standards, believes that the TCP/IP protocol "helped turn data transport into a commodity business and put the power in users' hands, not in the centralized telecommunications companies' controlling grasp" (Gilmore 2002). The protocol works on top of all possible computer networks, adding a layer fully open to innovation and creating a neutral communication channel that is non proprietary and does not set requirements for either the underlying hardware or the application layer above. This is the so called End-to-End model, in which all the "intelligence" is placed at the end of the connections while the data is transferred with the help of a "dumb" protocol, responsible only for reliable data transmission.

By 1980, it was decided that a network-wide transition to the TCP/IP protocol will be made. This would allow ARPANET to connect with other networks and jointly become an inter-network: a virtual network consisting of several different networks. The original ARPANET network was split into two interconnected ones: the MILNET network supporting operational requirements of the military and the ARPANET research network. On 1 January 1983, the switch to TCP/IP was made and the Internet is born, unified by a common protocol and freed from military influence. The 1980s observed growth of another important network, the academic NSFNET network developed in the United States by the National Science Foundation (NSF). NSFNET quickly replaced ARPANET as the more important computer network and ARPANET was decommissioned in 1990. Two administrative decisions concerning NSFNET had a crucial effect upon the Internet: to restrict NSFNET use to noncommercial activities and to make TCP/IP an obligatory protocol. The former on one hand served to promote the free, non commercial culture of the Internet but, according to Gilmore, created as well an incentive for the growth of a commercial backbone and service providers, effectively stimulating growth of the network infrastructure. The later decision, coupled with large scale funding of the network by the NSF, allowed TCP/IP protocol – used on the NSFNET - to marginalize by 1990 other network protocols and to become "the bearer service for the Global Information Infrastructure" (Leiner et al. 2000). In what was a fortunate move, rejection of TCP/IP by telecommunication standards bodies allowed the protocol to remain open and beyond the control of telecommunication operators and regulating bodies. Thanks to the TCP/IP protocol, Internet became the only public global communication network open to institutional, corporate and individual use. Rapid spread of digital communication was fostered thanks to the flexibility of the architecture and lack of proprietary control.

The World Wide Web

In 1991, another revolutionary invention was made as Tim Berners-Lee, a researcher from the CERN physics research center, created the World Wide Web (WWW). WWW is a content layer placed upon the communication software and physical hardware layers of the Internet. While "the Internet ('Net) is a network of networks. Basically it is made from computers and cables […], the Web is an abstract (imaginary) space of information." (Berners-Lee, Press FAQ).

The WWW is a hyperlinked information space, existing at a global scale due to the fact that the Internet was there, providing a necessary infrastructure. But the history of similar efforts goes back to 1945, when Vannevar Bush published an essay titled "As We May Think" (Bush 1945). Bush envisioned a machine, which he called a Memex (short for memory extender), able to organize stored information based on association, and not just indexing, much like the human brain. Memex was described as a "mechanized private file and library" placed inside an ordinary desk, which serves as "an enlarged intimate supplement to his [individual's] memory" (Bush 1945). Crucially, Memex would allow the user to create trails that link separate items, so that "any item may be caused at will to select immediately and automatically another" (Bush 1945). By building "trails of interest", individuals could make useful and meaningful the "enormous mass of the common effort" (Bush 1945), providing a solution to the problematic fact that scientific research was too successful and amount of information was beginning to overwhelm our coping capacities and attention spans (Rheingold 2000).

In 1950, Doug Engelbart, an electronic engineer, also became interested in creating a mind-extending technology and like Bush believed that humanity lacks adequate tools to deal with ever more complex and urgent global problems. Engelbart was motivated by deeply humanistic goals, believing that "If you can improve our capacity to deal with complicated problems, you've made a significant impact on helping humankind" (Engelbart, quoted in Rheingold 2000). In 1962, Engelbart published "Augmenting Human Intellect: A Conceptual Framework", in which, as Licklider did earlier, he set to describe a symbiotic entity that "will exhibit more of what can be called intelligence than an unaided human could" (Engelbart 1968, 64). Human capabilities, according to Engelbart, can be extended through four means: physical artifacts, language, methodology and training. Engelbart understood that although artifacts are a low-level component, even minor changes at this level could bring total changes to individual problem solving capabilities, which are "possibly the most important resource possessed by a society" (Engelbart 1968, 90). Engelbart created an augmentation laboratory at the Stanford Research Institute (SRI) which by 1968 managed, with IPTO funding, to create the NLS (oNLine System), an experimental hypermedia time-sharing system, which included such innovative technologies as a mouse, hypermedia, teleconferencing and a "windows" interface. Engelbart went on to consider "team augmentation" in groupware systems and predicted emergence of "personal augmentation systems linked together into network communities" and a "new marketplace representing fantastic wealth in commodities of knowledge, service, information, processing, storage, etc." (Rheingold 2000).

The NLS was being created in a process of constant improvement, with the goal of transcending itself every 6-8 months. Constructors of the system were also its users and it is interesting to note, that even among this group, which can be considered a "knowledge elite", users began resisting constant change. Ultimately, Engelbart's system, although powerful, proved too complex to become widely used.

In 1965, Ted Nelson used the term "hypertext" to describe a linked network of information that can be navigated by readers in a non-linear manner. Nelson went on to envision a system of connected literature called "Xanadu", which he envisioned as "a magic place of literary memory" with the potential of becoming a docuverse – a universal text network that connects all information. The system would also uphold an intellectual property system, since the network would monitor transmissions and pay royalties to the creator of every displayed information. This was a libertarian dream, of a free market supporting a vision of fair use of information, without intervention of government or corporations (Streeter). Nelson also believed that the technology would have the potential to create social forms shaped by individuals beyond the command of central control (Rheingold 2000). Ultimately, Nelson hoped, common knowledge will draw together everyone: "We want to go back to the roots of our civilization – the ability, which we once had, for everybody who could read to be able to read everything. We must once again become a community of common access to a shared heritage" (Packer 2001, 161).

In the 1980s, Berners-Lee created, for personal use, a program called Enquire, which functioned as a "memory substitute". Enquire was able to track random associations between facts and ideas, which "brains are supposed to be so good at remembering but sometimes mine wouldn't" (Berners-Lee, Press FAQ). Data stored in the Enquire was interconnected through links. A concept of a network of connected Enquire systems, led Tim Berners-Lee to imagine a system earlier envisioned by Nelson and Engelbart. But in the 1990s, the Internet was there to make such an interconnection into a global hypertext space possible.

“Common information space” created by Berners-Lee is based on three key elements: 1. HTML markup language, 2. URIs (Universal Resource Indicators) and the HTTP protocol, 3. hyperlinks, through which related content can be linked in a non-linear way, forming a dense web of related information.

Berners-Lee had a “dream behind the Web” – of a “common information space in which we communicate by sharing information” (Berners-Lee 1998). He stressed universality of the system, with hypertext links pointing to anything possible. Just like the TCP/IP protocol, the WWW was a highly open environment, with the design based on such criteria as universal linking, availability on all platforms and lack of constraints on mental models of data that users have. On the other hand , the WWW was autonomous: “For the information space to be a powerful place in which to solve the problems of the next generations, its integrity, including its independence of hardware, packet route, operating system, and application software brand, is essential” (Berners-Lee 1996).

Like the creators of time-sharing systems, Berners-Lee hoped that human-computer interaction should become intuitive: “The interaction between person and hypertext could be so intuitive that the machine-readable information space gave an accurate representation of the state of people's thoughts, interactions, and work patterns” (Berners-Lee 1996). Intuitively collected information would form “a realistic mirror (or in fact the primary embodiment) of the ways in which we work and play and socialize” (Berners-Lee) and machine analysis of this Web would both benefit individual lives and become a powerful management tool. The vision was similar to Licklider’s concept of computer-aided modeling: “We have seen that the Web initially was designed to be a space within which people could work on an expression of their shared knowledge” (Berners-Lee 1996). Looking at the Web in 1998, Berners-Lee stated that the flood of materials made the Web what he dreamed it to be: a common information space.

Berners-Lee understood that by designing protocols the inventors were addressing ethical and social issues. Network protocols can work just like a social or legal force, requiring “laws of our countries […] to work hand in hand with the specifications” (Berners-Lee 1996). The basic functioning of the Web, Berners-Lee seems to hope, should be independent from legal and political constraints. Therefore Berners-Lee’s invention meant a qualitative difference, since by following links users could now interact with a holistic, unified information space. This space is commonly perceived as independent of both its authors and hardware and protocols upon which it is layered. We can consider interaction between a user and the WWW as one more distinct form of communication made possible by global computer networks.

Key characteristics of the Internet as a sociotechnical system

Development of the global computer network and later the Internet included three key designs tied to value decisions. Among key Internet technologies developed are: 1. A network of time-sharing computers acting as peer nodes of a decentralized packet switching network; 2. a software protocol uniting the network of networks by providing open architecture and interactivity between host computers; 3. a universal structure of information with full interlinking capability and free access were created.

As early as the 1960s, the first inventors of Internet technologies identified key social effects of the Internet: individual development and improvement through interaction with first a computer and later a computer network, creativity afforded by pooling of resources and creative forces into one information space and computer-mediated forms of social life.

The Internet can also be seen as a layered sociotechnical system. Lawrence Lessig distinguished three layers of the Internet: physical, logical (or code) and content layer, arguing that software protocols, which form the logical or code layer, shape the basic architecture of the Internet and thus serve a function comparable to that of a constitution in the institutional structure of a society (Lessig 1999). Engineers described in this text have provided key elements for each of these layers: 1. the hardware infrastructure of a decentralized packet-switching network; 2.the software protocol layer formed by the TCP/IP and a host of other free protocols; 3. the universal information space of the WWW at the content layer. Since we consider the Internet a sociotechnical system, we can imagine one more layer, a social one, on top of the other three and interacting with them. Imagining social institutions and values as comprising one of Internet's layers stresses the fact that these are an integral element of the system.

One key element of this social layer needs to be mentioned: the "Information wants to be free", attributed to Stewart Brand, a researcher from MIT who stated: "On the one hand information wants to be expensive, because it's so valuable. On the other hand, information wants to be free, because the cost of getting it out is getting lower and lower all the time. So you have these two fighting against each other" (Clarke 2000). The slogan expressed a simple truth that progress of communication and computer technologies makes access to information easier. But, as Internet activist John Perry Barlow observes, it also "recognizes both the natural desire of secrets to be told and the fact that they might be capable of possessing something like a 'desire' in the first place" (Barlow, quoted in Clarke 2000). "Information wants to be free" became a catchphrase for what can be described as intellectual, if not social, movement based on an assumption that increasingly "free" information is in itself a value[4].

A belief that humans gain freedom by freeing information is also implicitly stated. Looking at motivations behind the creation of Internet technologies, we can consider them all guided, to an extent, to a similar belief that information wants and should be free. If we agree with Barlow that information can be treated as an autonomous actor, then the Memex, time-sharing computers, packet-switching networks and World Wide Web are first of all not means of empowering individuals and of ushering in institutions of the network society, but means of freeing information from constraints such as those of the failing human mind, of inadequate computing power or of spatial barriers to information flow. As Lucy Suchman suggested, creators of the Internet might have been at times more intimate with the world of information than with the world of humans, making Latour's suspicions of the condition of technical democracy justified.

Internet and the Values of the Information Society

By comparing the Internet with the Telegraph, Tom Standage shows that new communication technologies have always been met with large social optimism. "All the inhabitants of the earth would be brought into one intellectual neighborhood" (Standage 1999, 194) stated an advocate of the Internet in 1846. In 1997, Michael Dertouzos envisioned "computer-aided peace", believing that "a common bond reached through electronic proximity may help stave off future flare-ups of ethnic hatred and national breakups" (Standage 1999, 194). Utopian thinking runs through a large part of theories of the information society, culminating in Yoneji Masuda's mystical vision of "computopia", the universal information society of plenty (Kumar 1995). We mention the concept of information society, because it was developed in parallel with Internet technologies. Values of the early Internet creators often coincide with key values of the information society. Information society theorists track a qualitative and quantitative increase in knowledge. The society is transformed as knowledge becomes the new source of value and information industries and knowledge jobs dominate the economy (Kumar 1995).

Social concepts of Internet's creators were focused on the issues of improving research, scientific work and knowledge management, seeing these as crucial areas of social life. The computer network was seen mainly as tools augmenting individual development and collaborative work, thus enabling the management of increasingly complex reality. Creation of computer-mediated

4 The concept also guided the creation of non-proprietary software, called free or open source software, which Manuel Castells considers "the key technological feature in the development of the Internet" (Castells 2002).

communities was not a design goal, but a coincidental effect that was welcomed and investigated by the engineers. It seems that early programmers, able to envision some social consequences of their inventions, had difficulties with thinking outside their organizational culture. Engineers envisioned communities of interest, freed from the bonds of common tradition or territory and tied by the new social glue of the common information pool. The time-sharing computers and later their network were the core around which a community formed in accordance with Masuda's belief that "information utility […] consisting of information networks and data banks […] will replace the factory as societal symbol" and have "the fundamental character of an infrastructure" (Kumar 1995, 12). Visionaries like J.C.R. Licklider were right in predicting that new forms of social life will spread in the society, but were wrong in not considering a possibly limited scope of such diffusion. Similarly, many theories of the information society predict total transformation of the society, while Daniel Bell more cautiously advises to consider "the disjunction of realms", with economy, politics and culture having different norms and rhythms of change (Kumar 1995).

Let us quote, once again, Licklider's and Taylor's description of affordances of the network technologies: "First, life will be happier for the on-line individual because the people with whom one interacts most strongly will be selected more by commonality of interests and goals than by accidents of proximity. Second, communication will be more effective and productive, and therefore more enjoyable. […] And, fourth, there will be plenty of opportunity for everyone (who can afford a console) to find his calling, for the whole world of information, with all its fields and disciplines, will be open to him-with programs ready to guide him or to help him explore" (Licklider and Taylor 1966). Missing from these blueprints are, to name just few: enjoyment stemming from ineffective communication, joys granted by "accidents of proximity" and life callings beyond the world of information.

For Internet's creators, access to technology became an important right in itself. Provision of universal and equal access was therefore seen as being of primary importance. Differences in access and ability to use telecommunication technologies were rightly considered as factors leading to new social divisions. Time has proven that, as Licklider and Taylor observed, responsiveness of humans is as important as institutional arrangements. Today, alongside the primary Digital Divide in access, a secondary divide in the ability to use and profit from available technologies is being tracked (Hargittai 2002). In a technical democracy, according to Latour (1998), it is essential that "the People" and not just a few individuals have to become "the Prince".

Looking closely at Internet's history, we observe many instances of what

Hughes calls unintended malfunctions of the sociotechnical system. These were caused by Internet's users, who acted against the momentum of the system and not in line with the roles prescribed to them as elements of the system by the creators. Janet Abbate shows how the ARPANET network, originally built to allow resource sharing, a form of computer-to-computer communication, was in the course of the 1970s used ever less for its original purpose. Instead, the possibility of human-to-human communication proved to be the "killer application": "Email quickly became the network's most popular and influential service, surpassing all expectations" (Abbate 2000, 107). ARPANET turned out to be a communications and not a computing system, guided by the idea "of the network as a means for bringing people together", in which interactions go beyond scientific exchange of ideas. Another significant example is provided by Howard Rheingold (2000), who describes how hackers working at MIT's Project MAC used state of the art computer technologies, which they themselves created, to obsessively play a computer game called Spacewar. Heterogeneous engineers of the Internet seem to have forgot to address the realities of everyday life and the importance of leisure in a reality that does not fully comply with an orthodox vision of the information society.

This shortcoming can partially explain radical changes that occurred to the Internet in the 1990s. Around 1993-1994, a period of commercialization and rapid diffusion of the Internet has begun, caused by a convergence of decreasing prices of the technology, increasing interest of commercial players, constantly growing WWW and breakthroughs in interface technologies. The mass users can be treated as a fifth culture that shaped the Internet together with the culture of the Internet entrepreneurs. Apparently, the momentum of the new technology was not sufficient and the sociotechnical system of the Internet has been reshaped. Today, computers and the Internet are often used for everyday communication and leisure. This has not been envisioned by creators of Internet technologies, who also failed to provide solutions for coping with such issues as "content, privacy, security and identity" (CSTB 2001). It is as if the Internet as a sociotechnical system has been divided into a fragment shaped by the culture of the creators and first users coexists and another, of commercial interests and mass users. The two coexist, tied by the common infrastructure, single protocol and information space.

Conclusion: the Internet and Technical Democracy

Bruno Latour suggests that in the hands of the few selected Princes, sociotechnical systems have the potential of becoming autonomous forces outside of democratic control, which remains blind to new flows of power. In order to change this, "the People" have to become intimate to an extent with technology.

An outdated theoretical model is, according to Latour, one of crucial obstacles to this goal: “social scientists are always a war late, seeing devious political plots behind techniques, when the socio-techniques allow [...] to add new fresh unexpected ways of redefining power” (Latour 1998). While the Prince appeals to both human and non-human allies, the traditional democrats still focus solely on fighting machinations, not machines.

Sociotechnical systems cannot be reduced to a social strategy, because we would then lack explanations for the “painless, quiet and necessary” spreading of technology. Social constructivism either sees technology as neutral or describes every invention as a material effect of a social plot, often hidden – of the multinationals, of capitalism, etc. On the other hand, their success cannot be attributed purely to the force of technology, since “Reduced to itself, it is as much a ghost as society. [...] It is not the solidity of the gathered [non-human] allies that counts but the solidarity it offers with other human struggles” (Latour 1998).

An analytical split between technology and society weakens democracy by allowing for two types of capitulations. One is an acceptation of technology as an autonomous force with own inertia, trajectories and complexity. The other one is based on an insistence that society is educated enough to check and control technological developments. These paralyze democracy, because suggest that changes can be brought about only by a new technology or new society. The Prince is left “perfectly free in his palace, unhindered, weaving at leisure human and non-human actors, redefining locally, as much as pleases him, what ties all of us together” (Latour 1998).

It is true that creators of Internet technologies acted beyond democratic controls, having crafted an institutional environment that allowed them to become intimate with cutting edge technologies, while autonomous of any external pressures, including those of broad democratic interest. Still, the Internet has been shaped to support such values as individual freedom and social equality. Although its creators were the benign, enlightened Princes, a democratic society can still be weakened by lack of understanding of the sociotechnical power of telecommunication technologies.

From the history of Internet's first creators several lessons can be drawn. First of all, they provide a model example of an engineer consciously addressing social issues alongside technical ones and caring for democratic values and not personal or commercial gain. Secondly, one can learn from the shortcomings of their visions. If the Internet remains a sociotechnical “front line”, then the developers need to constantly observe and address the manner in which the technology is used, so that unexpected usage does not become a malfunction of the system. A better understanding of broad social needs is necessary among engineers, which can specifically be obtained through social research on this issue. Bruno Latour suggests that technological revolutions are silent ones: “You expected to watch a show of force; you feel nothing but a violent desire to get in touch with your old mother **through the telephone** [my emphasis – AT]”. That most of us are not conscious of the extent technologies are reshaping our lives. If information technologies are to an extent autonomous and are characterised by great speed at which changes to them occur and complexity that makes their workings hard to be grasped, then out of concern for technical democracy, both creators and users are obliged to better understand the workings of the Internet in the society. In the spirit of Internet's creators, existing technologies can be used for this goal. After all, improved coping with complex reality was an important rationale behind their creation.

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