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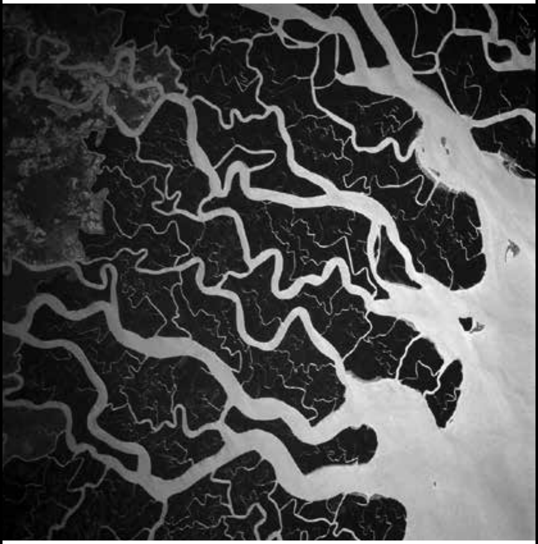
COMPUTER NETWORK HISTORIES

HIDDEN STREAMS FROM THE INTERNET PAST



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Paolo Bory, Gianluigi Negro, Gabriele Balbi

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Inhalt / Sommaire

zurück

Introduction: The Tributaries and Distributaries of Computer Network Histories

Paolo Bory, Gianluigi Negro, Gabriele Balbi

Long before the birth of the Internet, before the construction of roads, railways and highways, before the discovery of blood and neural systems, rivers were the main channels of communication and the world's "natural" networking infrastructure. In all continents, rivers were worshipped as gods with specific spirits. They provided water and fertility, like the Nile in ancient Egypt, the Amazon in Latin America, and the Yellow River in China. Rivers are also myths and symbols: they have played a role in the founding mythologies of cities like Rome (the two founders Romolo and Remo were saved by the god of the river Tiberinus) or were symbols of freedom in formative novels like Mark Twain's *The Adventures of Huckleberry Finn*. And, of course, rivers have always acted simultaneously as routes and borders between human communities. As other water gods, rivers are temperamental—sometimes calm, good divinities, sometimes furious and evil destroyers. Just like in our inter-networked world, river societies lived an instable, unpredictable life.

In line with Hu Yong's (2008) suggestion that the Internet and computer networks should be thought of through metaphors and analogies and in line with John Durham Peters' (2015) idea of including natural elements in media studies, we hereby propose that computer and river networks share many common features. Firstly, they are both communication and transportation infrastructures. In their respective realms, rivers and computer networks have been elective channels for the transmission of knowledge, for cultural and economic exchange or, in Harold Innis' terms (1950), means of communication. Furthermore, they are communication networks with hubs, points of exchange and switching and primary and secondary branches. Metaphorically, we browse, surf, and navigate the Web, along those streams that "the network of networks" opened up to human communication only a few decades ago.

Secondly, like many other essential infrastructures such as electricity and gas, rivers and computer networks are mostly invisible, both materially and symbolically. Only a minimal part of their material form emerges from the ground. Over time, thousands of underground streams generated by sudden rainfall and invisible creeks have stubbornly fed the Ganges, the Rio Grande, the Danube and many small and sometimes even disappeared rivers. Similarly, millions of copper and fiber optic cables running underneath our asphalt roads or undersea in the oceans sustain the global contemporary data network flow, providing societies with the greatest "basin" of information ever seen. They might also be invisible because they go unnoticed. If a river does not flood and a computer network works properly, we do not care about them, they are taken for granted, like the air we breathe. But when something does not work, we immediately take stock of their importance. Indeed, when we lose control over them, rivers and computer networks can create panic, destroying cities or interrupting human activities and communication.

Finally, rivers and computer networks are, at the same time, controlled and unstable. At some point in history, humans started to control rivers, deviate and block their flows and change their final destinations. As a critical turn in media scholarship has recently shown, this same act of "containment" is impacting computer networks. However, as Benjamin Peters claimed during his keynote speech at the *Computer Network Histories* conference (see below), networks remain "puckish creatures, they rarely do what we command them to do." The tension between an "out of control" network and a one whose flows have been interrupted, shaped and driven by private or public institutions has always been part of computer network histories.

This special issue originated from the *Computer Network Histories* conference, held in Lugano in December 2017 at USI Università della Svizzera italiana, incidentally a university located on Lugano's main river, Cassarate. The aim of this conference, generously sponsored by the Swiss Association of History and Informatics, was to gather together a group of scholars who have retraced some key-flows of the tributaries and distributaries of computer network history. Hidden streams, unexpected and disobedient flows enrich this special issue with new contents, characters and local experiences.

Notably, over the last century thousands of computer networks have been imagined, constructed and interlinked at national and international level by governments, scientific institutions and political organizations, or even by small communities and social movements. Like the thousands of small rivers that quenched the thirst of human communities in the past, computer networks provide various societies with unexplored forms of knowledge and information exchange thanks to their technological and infrastructural "nature." At the same time, these histories are not just histories of technologies, but also represent the vast heterogeneity of social, political and cultural networks that, globalization rhetoric notwithstanding, still characterize and define our times (Bory, 2019; Negro, 2017). The tributaries and distributaries of computer network history—even if at some point of their route these streams were blocked or subsumed by larger organizations and structures—contributed to the way in which today, even in our (partially) interconnected world, societies use, share and imagine technology. In sum, as Internet and Web historians have largely shown, there has never been just *one* internet. Neither is there just one history of the Internet, but rather a range of histories, some of them well known than others (think about the United States) and some unnoticed or still to be written (Goggin & McLelland, 2017).

Providing alternative and unwritten histories of computer networks is the aim of this special issue which includes six papers dealing with network histories from Central and Southern Europe, North and South America, India and South Africa. And there is also a final dialogue between the two conference's keynote speakers: an American scholar who has studied the history of the internet in Russia and a Chinese scholar who has been studying the internet in his own country since the 1990s. In combining different methodologies, sources and geographical case studies, the issue deals with various dimensions of computer networks: alternative visions of technology, political economies of different internets, grass root movements and private sector contributions in the creation of national computer networks. It stresses the importance of socio-technical issues such as encryption, materiality, digital activism and digital rights as well as the role of prominent and visionary scientists like the Italian Robert Fano.

More specifically, in the first article entitled *Thou Shalt Love Thy BBS: Distributed Experimentation in Community Moderation*, Kevin Driscoll provides a social history of the dial up boards system, also known as BBS. Driscoll focuses especially on what he calls distributed experimentation in the moderation of online communities in the 1980s and 1990s. This is a history of the unknown creation of a community infrastructure based on voluntary maintenance and participatory governance that later resurfaced on a mass-scale with contemporary social media.

This is the only United States based paper (after all, there are also understudied histories of computer networks in the US), while all the other papers are non-US based and deal with alternative histories of digital rights, digital network political economies, and finally, mostly unknown actors.

Two papers deal with grassroots actors envisioning alternative computer networks, digital rights and community participation "from below" in Europe and in Africa. Felix Tréguer and Dominique Trudel wrote *From Internet Access Provision to Digital Rights Activism*, a paper analysing the history of the French Data Network (FDN), the first community network

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and the Internet access provider open to the general public in France. While the history of computer networks in the country has been studied, especially from the perspective of big state actors (like France Telecom, Ministries of Posts), or champions of digital strategy like Nora and Minc, this article focuses on the role of grassroots actors and the formation of French digital rights activism from 1991 to 2011. In *Hacking Apartheid: Revolutionary Communication and the South African National Liberation Movement* Sophie Toupin examines the creation of an encrypted communication system by South African freedom fighters in the 1980s. This system was used to communicate secretly and transnationally in order to liberate people from apartheid. This case study frames hacking as a political, social and technical practice embedded in a national liberation movement and focuses on the pre-Internet era. Before the Arab Spring, and prior to the Internet being seen as a tool of democracy, computer networks were also tools for political action.

Alternative political economy of digital networks is a second macro-topic of this special issue. When we say alternative, we mean histories of digital networks which are not US-based, and histories of political economy of communication which consider the role of technology and adopt an STS perspective. Computer networks are thus often imagined as digital networks, completely separate from old analogue telephone networks. This is simply wrong and Christian Henrich-Franke in his *Computer Networks on Copper Cables: From the 'Promises to the Public' to the 'Profits of the Providers'* provides a German case study illustrating this. Franke highlights the importance of twisted pair copper cable infrastructures (those of the traditional, 19th century and analogue telephone networks) for computer network history. The copper cable network was indeed the infrastructure on which "the Internet" and "the Web" started to flow into private households and be used by mass audiences. This is ultimately a paper on how 'analogue technologies' have always played a key-role in the so-called digital transformation of our societies (on the relation between analogue and digital media see also Balbi & Magaudda, 2018). In other words, it proposes a new analogue and telephonic history of digital computer networks. Marcelo Savio and Henrique Luiz Cukierman analyse the origins of the Internet in Brazil from the early 1980s to today. Brazil is one of many countries in which computer networks were established in connection with and emulating the United States (and especially ARPANET) but with political, economic and socio-cultural peculiarities. The political dictatorship, first of all, envisioned a centralised and vertical computer network, mainly connecting universities and research centres. Ultimately these connections did not work well, mainly because of a lack of networking standards and because private companies entered the internet business in the mid-1990s. Secondly, in contrast to the US, in Brazil there was an urgency of international connections right from the start, mainly with other Latin American countries. Early computer network histories are not only national but also, and especially, transnational (as Sophie Toupin's paper shows) and so digital historians should find new methods and sources to enquire into and research international archives.

Benedetta Campanile's paper focuses on a mostly unknown figure in computer network history: Italian-American computer scientist Roberto Fano. In the early 1960s, Fano launched Project MAC at the Massachusetts Institute of Technology and envisioned a new concept of cybernetics: "making the power of computers directly accessible to people." This is a story of the democratization of computer networks, of an alternative paradigm (opposing the centralised and oligarchic use of computers) which emerged in the hegemonic terrain of mainframes, and finally a story of an 'internet for all', far ahead of its time. This paper also offers a methodological insight: computer network historians should also follow people who swim in rivers for short distances. Metaphors aside, biographies are powerful tools with which historians can reconstruct not only personal stories, but especially environments, taken for granted ideas, and status quos that "special people" would like to break and change.

The outlet of this special issue is a dialogue between the two Lugano conference keynote speakers: American Benjamin Peters, who wrote a famous book on the history of the Russian internet (Peters, 2016), and Chinese Hu Yong, probably China's first internet scholars and one of its most important (see Hu, 1997). This discussion addresses relevant issues in the field, questioning and challenging the idea of network history, proposing alternative ways of talking about networks, providing key insights into how these have changed over time and highlighting the contributions of countries such as the Soviet Union, China and the United States. Finally, Peters and Hu stress the major challenges that scholars are facing in writing network histories but also the opportunities for further specific research in this field.

Our hope is that new paths will open up to readers in their mental maps of the networked globe, and that the streams flowing out of this issue may at least partially nourish the already fertile fields of internet and digital media history. Emblematically, any history, like any of the world's rivers, originates from a source and it is the sources of our contemporary networked world that we need to dig for, seek out and aspire to as historians. In order to navigate through this fuzzy present with clear coordinates, we first need to quench our thirst on the networked past.

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zurück

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Thou Shalt Love Thy BBS

Distributed Experimentation in Community Moderation

Kevin Driscoll

Abstract
The social history of dial-up bulletin board systems, or BBSs, reveals a period of distributed experimentation in the moderation of online communities. During the 1980s and 1990s, computer owners built dial-up BBSs wherever public switched telephone networks were available. Through the ritual of dialing-in, reading messages, and posting replies, local BBS users came to see these low-cost platforms as valuable community infrastructures. The stability of this emerging online world relied on the voluntary maintenance work of BBS administrators, known in the community as system operators or "sysops." BBS sysops played a vanguard role in the design and administration of social computing systems. Ranging from technocratic tyranny to participatory governance to total lawlessness, the moderation policies and practices of BBS sysops shaped the experiences and expectations of early modem users. In their efforts to cultivate dedicated communities on their small networks, sysops encountered social, political, economic, and technical challenges that would later resurface on mass-scale systems such as America On-Line, YouTube, and Facebook.
Through an archive of how-to documents, legal advice, user policy agreements, and satirical essays, this paper examines a sample of moderation practices taken up by BBS sysops during the 1980s and 1990s. The analysis focuses on moments of contact between sysops and users, including the recruitment, registration, and orientation of new users; the day-to-day regulation of user behavior; and the promotion of select users to "co-sysop" status. These practices unfolded against a backdrop of increasing commercialization. But rather than scuttle existing social norms, the demands of commercialization forced sysops to consider the moral and legal dimensions of community moderation. While some came to see their callers as "customers" instead of "users," others endeavored to create new socio-technical arrangements based on trust, communication, and mutual interest.

Circulated in emails, posted to forums and reproduced in electronic newsletters, a tongue-in-cheek document titled, "The 30 Commandments of BBSing," offers a glimpse into the social life of a typical dial-up bulletin board system, or "BBS," at the outset of the 1990s.[1] Self-consciously silly in its Early Modern affectation, the list nevertheless conveyed sincere recommendations for neighborly online behavior. The thirty rules ranged from technical practices ("Thou shalt delete thine ancient mail"), to social norms ("Thou shalt not post other users' real names"), to administrative requirements ("Thou shalt not giveth any false information when applying for membership to thy BBS"). In total, the "commandments" portrayed BBSs as novel social spaces that required new norms, new manners, and new common sense.

BBSs were sites of experimentation in community moderation. While the author of "the Commandments" remained anonymous, an introductory paragraph credited a "very intelligent" administrator for dedicating "great thought" to the problems that plagued BBS communities. Indeed, those individuals who set up BBSs did so with little guidance and no formal training in the management of online communities. As conflicts arose, BBS operators responded on an ad-hoc basis, idiosyncratically creating and modifying the rules for their BBSs. Further adding to the experimental spirit of the 1980s, there was little standardization from one bulletin board to the next. Only toward the end of the decade, with the rise of commercialization, did BBS operators begin to adopt boilerplate legal language to proscribe the activities of their users.

Recently, scholars have begun to examine moderation in the context of social media platforms such as YouTube and Facebook (Gillespie, 2018; Roberts, forthcoming). In *Custodians of the Internet*, Tarleton Gillespie argues that setting and enforcing rules about acceptable speech and user behavior is an "essential, constant, and definitional" feature of all social computing systems (Gillespie, 2018, p. 207). And yet, in his analysis of 21st century platforms, Gillespie found relatively little variation in their moderation policies and practices. To address the problems of harassment and misinformation, Gillespie argued, platforms need to focus their innovation efforts on creating opportunities for users to participate in the design and regulation of social spaces; to "share the tools to govern collectively" (Gillespie, 2018, p. 212).

The homogeneity of platform moderation in Gillespie's study is an aberration in the history of social computing. During the 1980s and 1990s, bulletin board system administrators, or "sysops" experimented with an array of moderation policies and practices, ranging from technocratic tyranny to participatory governance to stubborn lawlessness. Indeed, BBS sysops played a vanguard role, shaping both the experiences of early users

1 Four variants of the "commandments" are stored in the collection of BBS materials at textfiles.com (May B. Everyone, 1992; "The 30 Commandments of BBSing," n. d.-a; "The 30 Commandments of BBSing," n. d.-b; "The Twelve Commandments of BBS Users," n. d.).

as well as the future development of social media platforms. In their efforts to cultivate community on small networks, sysops encountered social, political, economic, and technical challenges that would later resurface on the mass-scale systems of the 21st century. To date, however, little historical research has focused specifically on the moderation work of BBS sysops during the 1980s and 1990s. What types of interventions did they undertake? How did they balance technology, policy, and social pressure to guide users' behavior? Did an interest in commercialization conflict with efforts to cultivate a sense of community among users?

Answering these questions depends on textual analysis of a range of primary sources including "born digital" documents such as "The 30 Commandments," source code, executable software, hobbyist magazines and trade literature. This paper relies specifically on the "BBS Textfiles" collection maintained by self-described "free-range" archivist Jason Scott at *textfiles.com*. In a short preamble, Scott explains that the 389 documents in this collection concern "the actual nuts-and-bolts issues, heartaches, triumphs, and wonder of the BBSs themselves." They include advertising, policy documents, editorial essays, personal memoirs, satire, and technical reference, all of which circulated through the BBS networks during the 1980s and 1990s.

In addition to digital sources, this paper draws on the author's own archive of print materials, acquired from used booksellers, flea markets, and swap meets between 2010 and 2018. This collection includes over one hundred technical manuals, how-to guides, reference books, and commercial software packages aimed at BBS users, sysops, and entrepreneurs. Complementing these archival materials are retrospective accounts from former users, typically posted to blogs and forums, or captured by the makers of documentary films (Hoekstra, 2013; Scott, 2005). Although the lived experience of accessing BBSs was ephemeral, the activities of the BBS period left an abundance of trace artifacts to analyze.

Who is responsible for a bulletin board system?

For many internet users, "BBS" is generic terms for an online forum (Raymond, 2003). In this paper, BBS refers to small-scale services hosted on personal computers and accessed over the public switched telephone network. The origin of this type of "dial-up" BBS is conventionally traced back to the technical culture of computer hobbyists in the United States in the late 1970s (Delwiche, 2018; Driscoll, 2014, 2016). Prior to its use in the context of computer networks, "bulletin board" referred to a physical wall designated as a space for posting notices of public interest. In the 1970s, computer enthusiasts in the United States took up the community bulletin board as an model for information sharing among strangers (Christensen & Suess, 1978). The present analysis is limited to the United States but BBS networks connected microcomputer owners throughout the transnational telephone system (Bush, 1993; Furman, 2017; Liang, Yi-Ren, & Huang, 2017; Reunanen, Wasiak, & Botz, 2015).

The BBS phenomenon flourished in the context of widespread adoption of the home telephone (Federal Communications Commission, 2003). The telephone network provided computer hobbyists with a ready-to-hand infrastructure for data communications. Meanwhile, the geographic reach of each BBS was constrained by the telephone system's billing structure. Telephone companies in the U. S. billed calls at different rates depending on distance and time of day. Placing a call beyond one's local area could be very costly so modem owners tended to limit their activity to geographically proximate systems. As a result, dial-up BBSs developed idiosyncratic cultures reflecting the interests, norms, and values of their local populations.

For enthusiasts and entrepreneurs in the United States, the barriers to starting a new dial-up BBS were relatively low. To begin, one needed a personal computer, modem, telephone line, and host program. While these materials were not cheap, the total cost was roughly comparable to other technical hobbies enjoyed by men of the period such as operating an amateur radio station or tinkering with a classic car (Haring, 2008). Furthermore, no official approval from the telephone company was required to attach a BBS to home telephone line. An individual could conceive, assemble, and launch a new BBS in a weekend. By the end of the 1980s, most metropolitan areas in the US were served by a dozen or more BBSs running out of the homes of hobbyist volunteers.

The people who hosted BBSs were known as "system operators" or "sysops." Initially, the sysop was simply the owner of the BBS, responsible for maintaining the technical infrastructure and paying the bills. Soon, however, sysops discovered that their responsibilities extended into the social lives of their systems. BBSs open to the general public became meeting places for strangers. In moments of conflict, sysops became mediators. They were the makers and enforcers of social policy. Ultimately, the sysop possessed a form of total authority because they lived under the same roof as the host PC. In a moment of frustration, the sysop could always pull the plug and shut down the whole system.

Although the sysop enjoyed almost unlimited control over the system, there remained a peership between sysops and users. In most cases, users and sysops owned comparable machines and held comparable expertise about them. The barriers to creating a new BBS were sufficiently low that

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any user or group of users were, in principal, free to depart and create their own system. In practice, the day-to-day costs of operating a BBS were not insignificant, but, on every board, there existed the potential for a user to step into the role of a sysop. The freedom for users to leave a system placed a limit on the sovereign power of the sysop and contributed to a sense of mutual accountability between users and sysops.

One way to approach the history of BBSing is to imagine all of the BBSs in the world as a single, decentralized socio-technical phenomenon, comparable in size to contemporary military and research networks (Driscoll & Paloque-Berges, 2017). While individual bulletin boards came and went, the overall BBS network steadily grew from the late 1970s until the late 1990s. During this period, hobbyists and entrepreneurs operated more than 100,000 BBSs in North America (Scott, 2001). Membership on individual BBSs ranged widely from single-node systems shared among groups of friends to multi-node international systems such as The WELL with as many as 10,000 active users (Hafner, 1997, 2001). Sysops attracted users to their systems based on shared location, interest, and identity. Some organized their boards around particular technologies such as a favorite computer platform. Others, such as the amateur radio-oriented Elmer BBS in Fort Rucker, Alabama, focused on hobbies or professional affiliations (Horzepa, 1985). Still others provided access to information and social spaces for marginalized communities, for example, the Critical Path BBS run by HIV/AIDS activists and the transgender-specific BBSs linked through TGNet (Dame-Griff, 2018; McKinney, 2018).

The history of BBSs traces a period of distributed experimentation in the moderation of online communities. The low cost of creating a new system enabled many people to become moderators who would have remained mere users under other socio-technological and political-economic circumstances. While sysops informally shared tips and techniques, each BBS was wholly independent of the others. Absent any central authority or formal organization, sysop moderation practices varied from one BBS to another. Sysops created their own social policies and administrative procedures, enforced through tailor-made software programs and shaped by a unique balance of authority, autonomy, and accountability.

The practice of BBS moderation

Moderating a dial-up BBS involved a combination of technical, social, and administrative techniques and practices. Out of the box, BBS host software provided sysops with a set of choices for constraining the activities of their users. Depending on the specific host program, the options for moderation ranged from restricting the use of certain words to creating multiple classes of users, each with its own set of permissions. Even more fine-grained architectural changes were possible in the cases of software like RBBS that provided uncompiled source code (Mack, Goosens, & Azzarito, 1992). Sysops enjoyed considerable freedom in the technical structure of their systems, but there were few examples to guide their design decisions. Quite often, sysops continuously altered their boards' underlying technology in response to unexpected events in the community or direct requests from users. Ideally, this brought the system's software into alignment with the community's social norms, subject to the sysop's final authority. In some cases, however, sysops created explicit policy documents, typically in the form of online bulletins or new user "applications" that established ground rules for the BBS. As with so much of BBS culture, the resulting policy documents reflected the idiosyncrasies of their authors and varied in tone from mere boilerplate to the sarcastic, silly and outrageous.

With the expansion of commercial online services in the early 1990s, the authors of how-to books urged sysops to create explicit policy documents (Rose & Wallace, 1992). In 1993, attorney Herbert Kraft and software engineer Warren Clary published the *BBS Legal Guide*, a software package that provided sysops with template policy documents and annotated copies of relevant legal code, organized by state. Promotional materials for the *Guide* hailed sysops as a group of specialists in need of legal advice to avoid the "big, bad wolves" of law enforcement and personal liability (Kraft & Clary, 1993). On matters of piracy, pornography, libel and taxation, they argued, unprepared sysops put themselves at risk of losing control of their systems.

The "User Rules and Regulations" of the Altered States BBS in Stockton, CA provides an example of a BBS policy document that explicitly proscribed users' activities (Heim, n.d.). Located in a region of California known for the cultivation of marijuana, Altered States offered a range of counter-cultural information and services, including "online psychics" and discussions of occult literature (Hansford, 1993). Set in all capital letters, the "Rules and Regulations" laid out clear guidelines for user behavior in ten short statements. Rhetorically, the rules combined legal terminology with the technical argot of the BBS culture. According to the policy, users of Altered States were required to adhere to any applicable state laws and to avoid engaging in "criminal activities" ranging from copyright infringement to the circulation of child pornography. In their day-to-day interactions with the system, users were also restricted to a single "logon name" or online identity and asked to avoid posting "slanderous or obscene" messages in the "general" conferences (though the rules note that this language may be acceptable in some "special" areas of the board.) The consequences for violators included being kicked off Altered States and having the sysops of other nearby boards notified. The rules asked users to think of themselves as "guests" on the BBS and to "treat the system accordingly." To gain access to Altered States, would-be callers were required to print out the rules and send a signed copy to the sysop by mail.

In contrast to the legalistic language of the Altered States policy, other sysops took an "anything goes" approach to moderation. Refusing to create or enforce any rules, the sysops of these boards allowed any behavior on their boards so long as it did not damage the underlying system or attract the attention of law enforcement. This unmoderated approach was clearest in the case of so-called "slam" boards on which insulting other users was not only tolerated by sysops, but encouraged. One former user described the nature of a "slam" as "a lengthy insult that was creative or especially demeaning" (Mirage, 2004). While participating in voluntary flame wars was certainly not to every modem owner's taste, the teen boys who populated slam boards were drawn to the hands-off approach of their moderators.

Anything-goes boards were the exception, however, and it appears that most sysops of the 1980s engaged in some form of moderation to constrain the behavior of their users and cultivate a particular form of community. In the absence of formal training, sysops were left to improvise. In the course of typical operation, a BBS provided a few key moments at which sysops might exercise their power and influence as moderators. First, the process of joining a bulletin board offered several opportunities for sysops to introduce first-time callers to the rules and social norms of their systems. Second, sysops aimed to encourage participation among established users by maintaining the technical functions of the BBS and stepping in to resolve conflicts between users. Third, when a BBS grew too large for a single person to moderate, sysops tended to share moderation responsibilities with "co-sysops;" community members who were granted privileged access to the underlying system software.

Intervention 1: Recruiting new users

The character of a BBS community—its norms, conventions, values, in-jokes, and favorite topics—were fundamentally shaped by the people who showed up, day after day, to post messages, download files, and play games. All BBSs involved some type of advertising or recruitment. Unlike videotex systems, the World Wide Web, or, indeed, the voice telephone network, there were no central directories for discovering new BBSs. Likewise, no public search engines existed to aid modem owners in finding new system. Outside of classified ads and BBS listings printed in the back of special

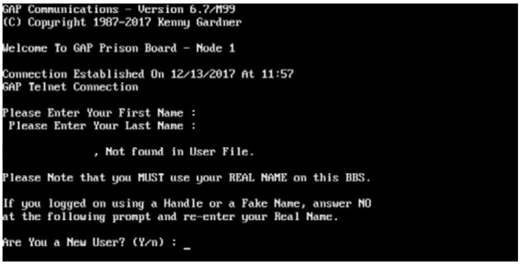

Fig. 1: Default new user prompt on GAP BBS host software. Screenshot taken using The Crow's Nest BBS on December 13, 2017. See: http://ww2.crowsnestbbs.us:8080.

interest publications such as *Computer Shopper*, it was up to BBS sysops and their users to spread the word and attract new callers to the system.

Word of mouth was a powerful mechanism for attracting new users to a BBS. The problem with word-of-mouth, however, is that the word rarely travels beyond the mouths of particular groups of people. This structural limit partially explain why white middle class men tended to dominate most North American BBSs; word-of-mouth spread through their relatively homogeneous social networks. This was not a foregone outcome, however, and some sysops endeavored to create systems that did not simply recreate the demographics of earlier technical hobbies.

For sysops aiming to cultivate a different kind of community, active recruitment was an important part of moderation. Perhaps the two best-documented cases of active recruitment were The WELL in Sausalito, CA and ECHO in New York City, NY. To cultivate a counter-cultural community on The WELL, the moderators invited artists, intellectuals, journalists, and other popular Bay Area figures to act as "hosts" in various forums (Hafner, 2001). In a contemporary account of this system, Howard Rheingold compared the resulting community to a Parisian salon with a more "elevated" discourse than other systems (Rheingold, 1993, p. 42). ECHO sysop Stacy Horn, meanwhile, aimed to attract more women participants to her system. In 1991, Horn provided free memberships to women and by 1993, 37% of the members were women and ~50% of the conferences were hosted by women (Bowe, 1993). Recruitment could be an effective strategy for upending conventional BBS demographics.

Intervention 2: Registration and orientation

In addition to advertising and recruiting, sysops engaged with new users through a process of registration and verification. First-time callers rarely gained access to the full features of a BBS. Instead, the BBS host program

Fig. 2: "Hello" screen from the Programmer's Mark BBS. Retrieved from: www.textfiles.com/artifacts/718/718-921-9267.

routed first-time callers into a registration process and added their information to a validation queue. The registration process typically consisted of a short questionnaire that would be stored on the host machine for review by the sysop. The structure and content of the registration system was entirely under the control of the sysop. The questions that they chose to include were a form of cultural communication that served a tacit screening function. If a user was alarmed or offended by the content of the questions, they were always free to hang up and save everyone the trouble.

Approving, or "verifying," new user applications represented an opportunity for sysops to screen potential community members. For hobbyist sysops, there were no social obligations, legal requirements, or economic incentives for accepting new users. Their BBSs were hosted on privately owned machines, in private residences, and they enjoyed total control over who was allowed online. One common practice involved calling new users on the telephone before granting them access. This technique, known as "voice verification" or "callback verification," provided a unique opportunity for BBS operators to get to know new users, set expectations, and orient users to the norms of the system. In a voice verification system, sysops called each potential new user on the telephone before approving their accounts. Voice verification was so common that it was built into the default settings of many BBS host programs, such as GAP BBS.

Voice verification offered an efficient mechanism for screening and orienting new users to the system. That first telephone call provided sysops with an opportunity to communicate the purpose of the BBS, set some ground rules, and answer any questions that the user might have. If a sysop could not reach a new user, or felt uneasy while talking to them, they were free to reject the application. To some degree, this brief moment of contact created an implicit social contract between the user and sysop. Each was accountable to each other after that first conversation. If we imagine the BBS as a kind of virtual house party, then voice verification gave users an opportunity to introduce themselves to the host. How many would feel comfortable trashing the place after that?

In addition to voice verification, sysops invented a number of other verification and registration requirements. New users on The Programmer's Mark BBS were asked to mail a self-addressed stamped postcard to the sysop's post office box in Brooklyn, NY (Negron, 1995). The sysop, Joe Negron, would return the postcard with the user's new ID and password. In fact, the postal network was a common medium for verifying new users. After requesting an account on ECHO, Stacy Horn mailed out a welcome letter with a temporary password and a helpful guide to using the system, including a quick reference card for the rather arcane keyboard commands.

Finally, some BBS users were verified simply by meeting the sysop in person. These sorts of face-to-face encounters might happen informally, such as a co-worker asking for access, or they might happen during an organized event such as a swap meet or meeting of a local computer club. Many BBS communities organized regular gatherings for their users, known as "get togethers" or "GTs." Whether meeting at someone's home or in a public place like a coffee shop or bowling alley, get togethers played several important functions in the life of a BBS community. For new users, get togethers offered a chance to meet the sysop and by-pass the voice verification process. Often, established users would invite a friend along to introduce them to the other members of the community. Spending a night hanging out with folks "from the board" helped newcomers to interpret the messages that later appeared on their screens. It gave faces, voices, and senses of humor to the other users.

Recruitment, registration, verification, and orientation are all examples of interventions available to BBS moderators interacting with new users. Each of these practices enabled sysops to shape the growth of their BBSs over time. For new users, these interventions could help to integrate them into the social world of the BBS and cultivate a sense of accountability to the existing community. Indeed, for systems populated by users within a local calling area, the consequences for transgression could spill out of the BBS and into voice telephone calls or face-to-face encounters. Likewise, get togethers presented new users with an opportunity to meet other active users of the system and accelerate the process of acculturation.

Fig. 3: "Your time is up!" cartoon by Ev Cheney, 1986. Retrieved from: www.textfiles.com/bbs/FIDONET/JENNINGS/IMAGES.

Intervention 3: Cultivating regular callers

BBS communities were sustained through the day-to-day interactions of individual people dialing into the system and contributing original messages and files. Unfortunately, because dial-up BBSs used a standard analog telephone circuit, rather than a packet-switched digital connection, most systems could host just one user at a time. While that one user was connected, anyone else who attempted to dial in would hear a "busy signal" and be forced to try again later. As a result, users took turns accessing the system, resulting in an improvised telecommunications carousel.

The social world of a dial-up BBS was embedded in an economy of time. On a single line, each day offered 1,440 minutes of time to share among all of the users. The liveliness of the community depended on the efficient allocation of those 1,440 minutes. If a single user stayed online all afternoon then there would be no opportunity for other users to get online. The forums and file areas would run fallow and the tempo of any online games would slow down.

For sysops of one-liner BBSs aiming to encourage community participation, the core moderation challenge was to accommodate the largest number of people as possible in a given day. This ensured that each time people called in, they would find new messages to read, new files to browse, and new events in the online games they played. To avoid discouraging potential callers, sysops needed to reduce the likelihood of being turned away by a busy signal. Striking the right balance required a savvy combination of social, technical, and administrative policies. To retain regular callers, sysops had to become managers of the economy of time.

Time limits, data limits, and speed limits were all social policies implemented in and enforced by software. The BBS interface displayed an on-screen clock to users, counting down the minutes and seconds remaining before it automatically dropped their connection. Data limits tended to be structured in terms of a ratio of uploads to downloads. The ratio encouraged users to be selective in their downloading rewarded users for contributing new files. Speed limits, a function of both time and data, emerged in response to the growing availability and affordability of "high speed" modems. These devices added a new dimension to the economy of time. Users connecting at high speeds operated in a fundamentally different temporality from their slower peers. Sysops encouraged the use of high-speed modems to reduce the time that users spend uploading and downloading large files.

Managing the economy of time was an essential practice for maintaining a sense of community on a dial-up BBS. Time, data, and speed limits maximized the availability of the BBS. These policies, built into the architecture of the platform, indirectly stimulated public communication by creating the possibility for a greater number of participants to read and post messages each day. Likewise, time limits could effectively diffuse conflict among users because they enforced a "cooling off" period during which neither party could access the system. Lastly, data transfer policies such as the upload/download ratio played a crucial role in shaping the file trading culture of the 1980s and 1990s. By incentivizing users to upload, they spurred on the exchange of files among BBS users in different regions.

Nearly all BBS software supported speed limits and download ratios but BBS sysops were not obliged to implement them. Some felt that ratios were an unfair burden to place on users, especially those who were paying for access. Stuart Smith, sysop of the engineering-oriented COMP-U-EASE BBS in San Jose, CA, offered a paid subscription option that freed users from the download ratio and provided access to subscriber-only phone lines (Petrzelka, 1991). Meanwhile, the sysops of the Knights In Shining Armor BBS in the rural town of Brooksville, FL required only local callers to keep up a file ratio; long distance callers were exempt. Other sysops did away with ratios altogether. Remarking on the absence of ratios on the MODern Music BBS in Healdsburg, CA, the sysop explained, "NO restrictions or ratios, because I HATE them on other boards" (Hunter, 1993). Inasmuch as ratios encouraged users to circulate files, they rarely involved an evaluation of the quality of uploaded files. As Wally Byczek of the Wallyworld BBS joked in a textfile aimed at would-be sysops, "If you impose an upload/

zurück

Fig. 4: The “Time Bank” on Tiny’s BBS. Retrieved from: http://tinysbbs.com.

download ratio … then you will receive 2K text files from them. They will download 2Mb of Gif files in return” (Byczek, 1989).

Yet, data and speed limits were common enough that the absence of a “ratio” became a mark of distinction for many BBSs. In 1987, when Rusty and Edwina Hardenburgh endeavored to build “the friendliest BBS in the world,” they decided to forgo time limits, byte ratios, and other “hassles” (Hardenburgh & Hardenburgh, 1990). Fellow enthusiasts warned the couple that they were making a mistake by flaunting this moderation norm. Reflecting on the early years of the BBS in 1990, the couple remembered being told that callers would do “terrible things” to a system that lacked any constraints on user behavior. Gratified to find that callers seemed to respect the system and uploaded new files voluntarily, the couple came to believe that a strict technical policy was not needed in a social atmosphere that felt “like home,” where callers could “relax … among friends.”

Intervention 4: Promoting users

Sysops were not the only BBS users to bear the responsibility of moderation. On many systems, moderation duties were shared among multiple “co-sysops.” While the primary sysop tended to own the hardware and pay the bills, co-sysops accessed the system remotely. Rather than focus on technical maintenance and improvement, co-sysops oversaw the day-to-day social needs of the BBS. In most cases, the co-sysop role was encoded in the underlying host software, granting special permissions to allow co-sysops to approve new users, manage existing accounts, maintain the file areas, or censor the forums.

The cooperative co-sysop model of moderation allowed for a range of routine practices and responses to conflict that were simply impossible in the autocratic model of the single sysop. The T.A.R.D.I.S. BBS in Indianapolis, IN was a community-oriented system founded by a group of four friends, two men and two women (O'Nan, 2006). In a similar spirit as the science fiction series Dr. Who, from which the BBS took its name, the four co-sysops endeavored to create an atmosphere of fun and friendship by designing humor into the system's interfaces and hosting regular get togethers. The founders were also especially committed to ensuring that the system was accessible to users of screen-reading software. After several years of operation, they maintained a user database with 3,500 registered users, about 750 of whom they believed were "regulars" and 40 of whom called daily.

One thing that set the T.A.R.D.I.S. apart from other BBSs in the Indianapolis area was an area of the BBS that was exclusively for women. The women-only area was moderated by the two women co-sysops and users had to be personally verified to gain access. One former T.A.R.D.I.S. user described the women-only area as an alternative to other systems where women were the targets of unwanted attention from men. In her words, other BBSs could be a "nightmare" with "all sorts of people hitting on you" (Scott, n.d.). Crucially, the men co-sysops stayed out of the women-only area—even though the hardware was stored at one of their houses.

Designating one or more co-sysops created new possibilities for designing and moderating the social world of a BBS. By sharing moderation responsibilities between men and women, for example, the T.A.R.D.I.S. was able to offer a unique environment for women users. For BBSs started by a single user, co-sysops might be promoted out of the general user population. This process of delegating responsibility reflected the mutual accountability of users and sysops. Selecting a regular caller to act as co-sysop signaled that the sysop recognized the expertise of the users, cultivating a sense of shared ownership in the future of the community.

BBS moderation took many forms during the 1980s and 1990s. The breadth of social, technical, and administrative practices undertaken by sysops and co-sysops reflected the independence of each BBS in the overall network. Although users and files moved among systems, each BBS was a world unto itself. This decentralized structure afforded BBS operators considerable autonomy to experiment with various moderation techniques. Sysops recruited, registered, verified, and oriented new users; they crafted policies to facilitate the participation of returning users; and they demonstrated their accountability to the community by appointing co-sysops.

Commercialization and community moderation

BBSs were sites of innovation in community moderation but they were also sites of commercial experimentation. The demands of commercialization and community might seem at odds but, in practice, they often overlapped. Indeed, cultivating a strong community was a prerequisite for commercial success. Unlike social computing enterprises of the dot-com era and after, dial-up BBSs depended on usage and membership fees for revenue, rather than advertising or data-mining. Therefore, sustainability required sysops to attract and retain users who routinely participated in the system by posting messages and uploading files. Consistent with this interdependence, the literature on moderation occasionally blurred the distinction between a successful business and a thriving community.

Initially, North American hobbyists ran dial-up BBSs almost exclusively on a not-for-profit basis. Early commercial systems like The WELL depended on an unusually large membership and the pre-existing reputation of *The Whole Earth Catalog*. Due to the low rate of modem ownership in the United States, few dial-up BBSs could hope to replicate the success of The WELL in the mid 1980s. By the early 1990s, however, a proliferation of low-cost modems and a bloom of interest in "the information superhighway" expanded the population of potential users. As a result, many BBS operators began to consider the possibility of turning their hobby systems into small businesses.

Commercialization forced sysops to convert implicit or informal moderation practices into explicit policies. Trade books from the publishers of technology manuals and textbooks such as Addison-Wesley, InfoLink, and Que, tended to frame moderation through the framework of commercialization (Allen, 1993; Bryant, 1994, 1995; Chambers, 1994; Wolfe, 1994, 1995). One author urged sysops to stop thinking about their community members as "users" and to start thinking about them as "customers" (Bryant, 1994). This single categorical shift had significant consequences for sysop's accountability. While earlier sysop-user relationships were based on a sense of mutual investment in the community, a vendor-customer relationship suggested a different form of obligation. Sysops were becoming service providers.

The language of moderation also shifted in the context of commercialization. The authors of trade literature recommended a rights-based approach. What "rights" do users and sysops have on a BBS? But questions about rights tended to be fairly easy to answer: BBSs were private spaces, operated by private people, using privately-owned machines. If anyone had rights, it was the sysop. Alan Bryant, the author who suggested thinking about users as customers, assured his sysop readers, "The truth is, you can censor any speech you wish, delete messages that offend you, expel users who say things you don't like—and you have the right to take any of those actions" (Bryant, 1995, p. 211). But, of course, he reminded readers, the culture of BBSing has always been about more than rights. These may not be the correct ethical choices, even if they are legally permissible.

Commercialization invited a discussion of legal rights but it did not absolve sysops of their accountability to the users on their BBSs. "You have the right to set rules," noted Bryant, "And while you don't have to, you should give serious thought to writing your rules down and making them available for callers" (Bryant, 1995, p. 210). Indeed, sysops may not have been bound by law but they were nevertheless bound by a moral obligation to their users. This implicit moral commitment suggested that sysops ought to alert users to rule changes, protect users' privacy, and provide advanced notice if they planned to take the system offline. These moral commitments were even stronger for sysops collecting fees from their callers.

Romantic histories of the internet occasionally portray early community networks as anti-commercial or radically not-for-profit. In fact, many BBS sysops were eager to experiment with novel forms of commercialization and happy to pursue entrepreneurial opportunities. Some of the best-known systems of the 1980s and 1990s, including The WELL, EXEC-PC, Software Creations, and ECHO were run on a for-profit basis. The pursuit of a sustainable business model did not prevent the formation of rich communities on these systems, however. Indeed, the pressure to state explicitly the rules of the system may have served as a form of de facto transparency that allowed users to feel more comfortable committing their time, attention, and money to the system. As a result, the practices of commercialization and community moderation are difficult to disentangle during this period. As Cliff Figallo of The WELL later observed, "The discussion and dialog contained and archived on the WELL are its primary products ... The WELL 'sells its users to each other'" (Turner, 2006, p. 146).

Conclusion

The origins of online community moderation are rooted in the history of dial-up bulletin board systems. The owners and operators of dial-up BBSs were dedicated to cultivating community on their systems and undertook a wide range of technical, social, and administrative interventions to moderate the behaviors of their users. This paper represents a small step towards documenting and classifying the various approaches to community moderation taken up by BBS sysops during the 1980s and 1990s. Many of these systems were also commercial enterprises, at least in part. Instead of advertising or data-mining, they drew revenue directly from users via subscription fees or per-minute charges. Future research might examine how the balance of community and commercial interests on BBSs compared with the same balance on contemporary "walled gardens" such as CompuServe or later social media platforms such as Facebook.

Dial-up BBS sysops enjoyed considerable autonomy in their moderation practices. This freedom was enabled by the relatively low barriers to creating a BBS, the independence of BBSs from one another, the small size of most BBS communities, and the geographic proximity of BBS participants. The scale and geography of BBSs communities are especially important characteristics to consider when comparing BBSs to later social computing systems. By verifying new users over a voice telephone call and hosting in-person "get togethers," BBS sysops made themselves accessible and accountable to their users to a degree that is simply not possible for the operators of mass-scale platforms. The author of the Commandments entreated users to "love thy BBS" because the thriving of a BBS community depended on the active participation, personal investment, and loving dedication of its users.

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From Internet Access Provision to Digital Rights Activism[1]

The History of the French Data Network

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Abstract
This paper chronicles the history of the French Data Network (FDN), France's first community network and first internet access provider accessible to the general public, from its foundation in 1992 to swarming through the Federation FDN in 2011. In France, the state played a central role in the development of early computer networks such as Cyclades, RENATER and Minitel. While these have already received scholarly attention, very little consideration has been given to political grassroots initiatives such as FDN and their role in co-shaping computer networks, their politics and their users. To help fill these gaps, this paper traces FDN's evolution from early concern with internet access and education to its more recent political commitments. In doing so, this paper simultaneously contributes to the development of a French national history of computer networks, to the ongoing diversification of digital rights activism historiography, as well as to future comparative research.

Based on interviews with the founding members and leaders of the French Data Network (FDN) (Benjamin Bayart, Laurent Chemla, Jean-Philippe Nicaise and Christian Paulus), this paper chronicles the history of FDN, France's first community network and first internet access provider accessible to the general public. In France, the state played a central role in the development of early computer networks such as Cyclades, RENATER and Minitel. While these have already received scholarly attention (see e.g. Schafer, 2012; Schafer & Tuy, 2013), very little consideration has been given to political grassroots initiatives such as that of FDN and their role in co-shaping computer networks, their politics and their users (Trudel & Tréguer, 2016; Pétin & Tréguer, 2018). To help fill in these gaps, this paper

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zurück

first traces FDN's evolution from its early concern with internet access and education to its involvement in the first campaigns to defend internet users' rights and early forms of digital activism in the mid-1990s. The paper then turns to the many challenges faced by FDN in the new context of powerful competition between commercial internet providers, rapid technological changes and a more restrictive regulatory framework. Finally, the paper discusses FDN's revival following the adoption of ADSL in 2005, and the organizational and strategic changes brought about by the creation of the *Fédération FDN* (FFDN), as well as the support given to WikiLeaks (2011) and the provision of VPN access to political dissidents during the Arab Spring (2011). In doing so, this paper simultaneously contributes to the development of a French national history of computer networks, to the ongoing diversification of digital rights activism historiography—one that has long been dominated by Anglo-Saxon perspectives (see Jordan & Taylor, 2004; Levy, 2001; Postigo, 2012)—as well as to future comparative research.

The early history of the French Data Network

At the end of the 1970s, personal computers finally came to France. At the time, magazines specializing in computer cultures reported that more than 100,000 computers had been sold in France (Thierry, 2012, p. 55). In 1985, an official report claimed that 860,000 households possessed a desktop device. By the end of the decade, France had become the top European market for PCs and over this period the number of computer clubs also rose significantly. This growth in computer use was facilitated by the government's voluntarist approach (Cats-Baril & Jelassi, 1994; Schafer & Thierry, 2012a). In 1978, when France was still lagging behind, the Nora-Minc report called for the unification of computers and telephone networks. That year also marked the would launch the unique experience of the Minitel (Gonzalez & Jouve, 2002; Schafer & Thierry, 2012a; Driscoll & Mailland, 2017). First intended as a way of giving the public access to databases, Minitel soon morphed into a communication device and a large-scale social experiment that led to the creation of France's earliest virtual communities. At the end of the 1980s, a quarter of French residents had access to Minitel. Other less popular computer networks were also accessible through dial-up connections, such as Calvacom, launched by Apple and the American College in Paris (Thierry, 2012).

All these early popular computer culture experiences, with their novices and "enlightened amateurs" (Schafer & Thierry, 2012b), were the backdrop against which the Internet swept through the country. In the early 1990s, as the Cold War came to an end, the Internet was growing and globalization increasing to such an extent that it would soon culminate in a historic democratization of communications (Gerich, 1992). At the same time, the Internet's political economy was turned upside-down by a mounting wave of neoliberal commodification that opened telecom markets up to competition (Jin, 2008; Pickard, 2007)

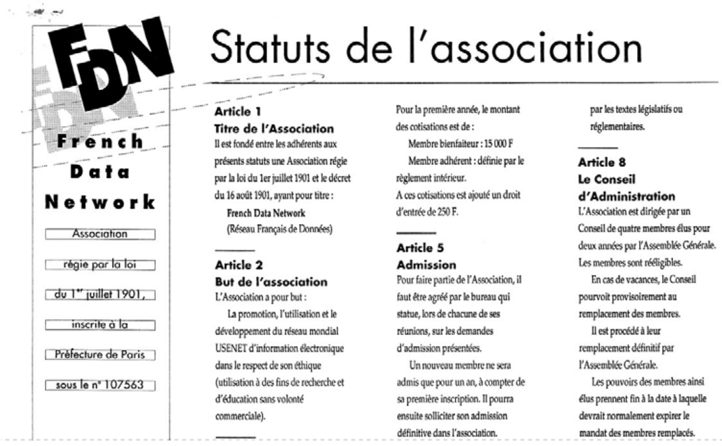
zurück

A non-profit association, the French Data Network, was founded in 1992, prior to the onset of Internet "dinosaurs" such as Netscape (1993), Yahoo (1993), Internet Explorer (1994) and MSN (1994). FDN was the "crazy idea" of Christian Paulus, a 35 year-old computer scientist, and a handful of Parisian computer enthusiasts, including Jean-Philippe Nicaise, Hubert Delahaye and Arnaud Weber (Nicaise, 2016). Meeting over dinner in February 1992, this small group of friends began planning for a new service that would bypass existing French networks and connect directly to American servers using UUCP.[2] Then the project's code names were "Fou du Net" and "Fou Fou Net" (Nicaise, 2016). Paulus and his friends were mainly interested in the Internet's educational potential and had very little experience with activism. At the time, they simply wanted to "open up this emerging worldwide library to everybody" (Paulus, 2016, our translation). The association was conceived of as a means by which to mutualize access costs, and in line with this principle of solidarity FDN offered discounted prices to students and the unemployed (Nicaise, 2016).

In May 1992, Paulus and his friends contacted U. S.-based service provider UUNET and succeeded in joining the UUCP and SMTP[3] crowd—on the strength of three NEXT computers (and attached UUCP modems) located first in Nicaise's apartment and later in Paulus' living room, in Paris (Nicaise, 2016). The following month, on June 2nd, the French Data Network was formally created, with Paulus acting as president, Arnaud Weber as vice-president, Jean-Philippe Nicaise as treasurer, and Hubert Delahaye as secretary. In the succeeding two years, approximately 400 people joined FDN, including about 25 non-profit and for-profit organizations acting as proxy for their members (Nicaise, 2016). Communicating on UUCP and exchanging emails on SMTP required having your own microcomputer equipped with a modem and UUCP free software such as FreeBSD or NetBSD (Jørgensen, 2001). Members paid annual membership fees of 100 francs (15 euros)—or 10 francs for students—and a monthly flat-rate subscription of 180 francs (27 euros) entitling them to a generous data allowance. Among other services, FDN provided users with their own IP addresses and configurable email services, and ran file-sharing servers

2 UUCP is an abbreviation of Unix-to-Unix Copy, a suite of computer programs and protocols first released in 1979 to provide for remote command execution, file transfer by email, and news bulletins between computers.

3 Simple Mail Transfer Protocol (SMTP) is an internet standard for electronic mail transmission, first released in 1992.



FDN

French Data Network

Association régie par la loi du 1^er^ juillet 1901, inscrite à la Préfecture de Paris sous le n° 107563

Statuts de l'association

Article 1
Titre de l'Association
Il est fondé entre les adhérents aux présents statuts une Association régie par la loi du 1er juillet 1901 et le décret du 16 août 1901, ayant pour titre :
French Data Network
(Réseau Français de Données)

Article 2
But de l'association
L'Association a pour but :
La promotion, l'utilisation et le développement du réseau mondial USENET d'information électronique dans le respect de son éthique (utilisation à des fins de recherche et d'éducation sans volonté commerciale).

Pour la première année, le montant des cotisations est de :
Membre bienfaiteur : 15 000 F
Membre adhérent : définie par le règlement intérieur.
A ces cotisations est ajouté un droit d'entrée de 250 F.

Article 5
Admission
Pour faire partie de l'Association, il faut être agréé par le bureau qui statue, lors de chacune de ses réunions, sur les demandes d'admission présentées.
Un nouveau membre ne sera admis que pour un an, à compter de sa première inscription. Il pourra ensuite solliciter son admission définitive dans l'association.

par les textes législatifs ou réglementaires.

Article 8
Le Conseil d'Administration
L'Association est dirigée par un Conseil de quatre membres élus pour deux années par l'Assemblée Générale. Les membres sont rééligibles.
En cas de vacances, le Conseil pourvoit provisoirement au remplacement des membres.
Il est procédé à leur remplacement définitif par l'Assemblée Générale.
Les pouvoirs des membres ainsi élus prennent fin à la date à laquelle devrait normalement expirer le mandat des membres remplacés.

Fig. 1: Snapshot of FDN's original by-laws (January 1993, J.-P. Nicaise's personal archives)

from which members could download free open-source software to manage their modems and configure their connections. The FDN community contributed to this software by writing bits of code and translating English technical documentation and tutorials to make them more accessible to French users. Paulus even attracted national visibility among French internet pioneers by translating *Netiquette*—the set of social conventions used by first Internet users to regulate online interactions (Hambridge, 1995). Overall, things were going smoothly. Revenues were much better than expected and more than covered expenditure.

The following year, FDN teamed up with RENATER, the newly-formed public national network for academic and research institutions (see Schafer & Tuy, 2013). In his professional capacity, Nicaise was invited to join a meeting organized by RENATER and learned about the institution's proposal to subsidize internet connectivity. Excited about the prospect, FDN's co-founders reached out to RENATER later that year, emphasizing its educational focus and special prices for students and job-seekers. A couple of months later, RENATER granted FDN a special 64 kilobits per second line to their data center providing an uplink to the worldwide internet, a router, a first batch of public IP addresses with which to connect their servers to the Net, as well as its *fdn.fr* domain name—all for a symbolic price. The team was ecstatic and by March 1993, after some engineering work, the new infrastructure was up and running, still on UUCP. Later that year, FDN switched from UUCP modem to IP connections and was able to offer real internet access.

By that time, FDN was operating in—and trying to make sense of—a new ambiguous context. On one hand, the Internet was becoming increasingly commodified, as e-commerce and online advertising developed rapidly. On the other, the mid-1990s witnessed a "renaissance" of social movements in France and the rise of internet activism—namely use of the internet by social movements adopting what Stefania Milan (2013) calls "emancipatory communication practices" (see also Granjon & Torres, 2012). The internet sparked a political movement of tech activists whose aim was "to bypass the politics of enclosure and control enacted by states and corporations" and achieve "structural reform at the grassroots level through the creation of autonomous spaces of communication" (Milan, 2013, p. 10).

FDN and the rise of digital rights activism in France

This new context coincided with a change in FDN's leadership. By 1995, Paulus and his friends had been replaced by a new generation of FDN leaders, as the former were busy developing their careers in the booming tech sector (today, one of them works at France Télécom Orange while another works at Google). In March 1998, following a brief period during which Fabien Roy served as FDN president and Sam Przysma as interim president, FDN's members elected a new young president named Benjamin Bayart, a computer scientist in his early 20s, ushering in a new, more political era in FDN history.

While the Internet was getting increasingly politicized, FDN members were loosely connected to early forms of internet activism such as the Freenix association (free software) and the worldwide Blue Ribbon campaign for online freedom of speech, organized in 1996 to oppose the adoption by the U. S. Congress of one of the first Internet censorship laws, the Communications Decency Act (Chemla & Bayart, 2016). Also in 1996, the French government initiated its first regulatory crackdown, heightening censorship and its surveillance capabilities. In response, a handful of French internet pioneers created the *Association des utilisateurs d'internet* (AUI), the first French organization formed to defend the civil rights of internet users (Pétin & Tréguer, 2018). A few months earlier, the *Réseau associatif et syndical* (R@S) was set up in the aftermath of the November-December 1995 social uprising against the pension reform proposed by the right-wing government of the day. R@S was a key player on the early French internet activism scene and one of the first to consider the Internet as a means for organizing social movements (Sauterey, 2005; Granjon & Torres, 2012). R@S teamed up with workers' unions and local

zurück

organizations involved in the Global Justice Movement—the worldwide movement opposing neoliberal globalization and institutions like the World Trade Organization and the International Monetary Fund—providing them with secure e-mail, free hosting services and innovative web-publishing tools (Papatheodorou, 2005; Granjon & Torres, 2012). This led to interesting forms of cross-fertilization. On the one hand, these new links helped to politicize the techies. On the other, it educated these older activist organizations on the Internet's radical-democratic potential and the ability to exert bottom-up control over computer networks, in particular through free software (Coleman, 2005).

Looking back into the Usenet archives, it is interesting to note that FDN is frequently cited in the discussions of those involved in setting up AUI and R@S (AUI, 1995). The reason was not only that FDN was—or had been—their Internet access provider, but also that for many, it was their most significant reference in terms of setting up and operating a non-profit organization (Tréguer & Trudel 2017).

The politicization of the Internet intensified further in the months that followed, in the aftermath of the so-called Altern Affair (Schafer, 2018; Pétin & Tréguer, 2018). Built by a young French programmer named Valentin Lacambre, *altern.org* was a free hosting service which faced numerous challenges and was a key player in the French debate on "intermediary liability." An appellate court decision eventually held Lacambre liable for the content published by Altern's users, leading to the 47,000 websites hosted on the platform being shut down.

From then on, FDN increasingly took part in the emerging French and international internet activism scene (Chemla & Bayart, 2016). For FDN's active volunteers, citizen-owned and run internet providers seemed to be a natural avenue for resisting to the trend to commodification and political control over the new communication infrastructure (Bayart, 2016). Though the leading members of the emerging digital rights scene did not necessarily perceive FDN's political potential, all shared the goal of equipping newcomers with technical know-how and cultivating an understanding of the Internet's political importance.

Maintaining technological relevance: a condition for political action

Despite the increasing politicization of the Internet in the mid-1990s, FDN soon had more pressing concerns to deal with than taking a leading role in this early internet rights activism scene. Indeed, the most pressing issue was maintaining FDN's core activity, i. e. internet access provision.

FDN had around 20 mostly commercial internet provider competitors in France (see Rebillard, 2012). In the context of rapid privatization, regulation promoted both the unbundling of last-mile as well as facility-based competition, and new companies began developing their own network infrastructure (Michalis & Ruhle, 2001). This, along with the mobile telephone communications explosion and the democratization of internet access, made liberalization seem like a success story: innovation in telecom services was dynamic and fast paced, prices were low and the number of internet users was surging.

It was becoming increasingly difficult for FDN to keep pace and compete with commercial providers such as Wanadoo, Free and Club Internet. In 1996 alone, when the Internet made its first general public breakthrough, FDN lost 10% of its members to commercial providers. In 1997, an extraordinary general assembly cast doubt on the very survival of the association (French Data Network, 1997). At the time, FDN was also facing up to the consequences of the new European directives then opening up telecom markets to competition and imposing new obligations on operators. To be registered as a lawful telecom player, FDN had to pay an annual fee of about 130,000 francs (20,000 euros) to the newly created national regulatory authority, the *Autorité de régulation des télécommunications*. The fee was designed for commercial players, and for FDN the sum was equal to its revenues. To avoid this crushing financial burden, the organization did not register and chose to remain under the radar (Bayart, 2016).

At approximately the same time, RENATER suddenly decided that FDN was actually operating a commercial service and dropped its support. FDN eventually switched from RENATER to Oléane, a business-to-business telecom operator who also provided batches of IP addresses, but on less advantageous financial terms. This led to changes in the association's bylaws, adopted in March 1998 at Bayart's behest. Article 2 of the bylaws now read: "The association aims to promote, use and develop internet and Usenet networks in accordance with its ethics by promoting, in particular, its use for non-commercial research and educational purposes" (French Data Network, 1998, p. 3, our translation). The meeting's minutes show that the phrase "in particular" was especially important—and ambiguous—in that it suggested "a less rigid framework for the evolution of the French Data Network […] clearly indicating our desire for openness to small scale entities such as craftsmen and small businesses" (French Data Network, 1998, p. 2, our translation).

In the mid-2000s, as connection speed significantly increased, thanks to the deployment of ADSL technologies, the situation worsened. By that time, FDN had only 40 subscribers, all of them using their slow FDN access for very simple and old applications. The bulk of their internet use relied on mainstream access providers.

From 1999 to 2007, FDN had stayed off the grid, holding no general assemblies, and its activities were less intensive than ever on the political front. Its few remaining members were mostly preoccupied with the very survival of the association in the face of taxation issues and commercial "high-speed" ADSL services. But those users who remained with FDN were the most committed to its values and mission, and were tied to the emerging digital rights movement, which underwent a revival in the late 2000s. This revival coincided with the adoption of ADSL in 2005, a project undertaken by Bayart who had been setting up an ADSL system for a mainstream operator (Bayart, 2016). After 18 months of internal lobbying, finding and talking to the right people, he managed to find someone in the business department of the company ready to make a special offer: that large telecom provider would lease parts of its network to FDN through so-called "bitstream offers." Rather than having to deploy its own infrastructure in the last-mile networks, FDN could rely on that of this much bigger operator in exchange for a per-subscriber fee.

In 2005, the roll-out of ADSL service brought FDN back into the game, on a technical level as well as in membership terms. At 29 euros per month, the subscription fee was comparable to that offered by commercial players, and FDN began recruiting new members (Sirjean, 2017).

The *Fédération FDN* and the second wave of digital right activism

Having secured the future of the organization, Bayart also became more politically involved in the mid-2000s, addressing crowds of free software activists at public events. At one famous speech that gathered much viewership online, Bayart described the Internet's enclosure and growing centralization as a move towards a "Minitel 2.0" (Bayart, 2007). This talk struck a chord in an increasingly politicized activist milieu. In 2008, Bayart also participated in the foundation of *La Quadrature du Net* (acting as the association's treasurer), a group that would go on to occupy the political space that had been left vacant since the end of the *Association des utilisateurs d'internet* in 2002 and the disappearance of another similar organization, *Imaginons un Réseau Internet Solidaire* (Pétin & Tréguer, 2018).

In 2009, FDN was a vocal opponent of French HADOPI law, which aimed to restrict peer-to-peer exchanges and disconnect internet users responsible for copyright infringements (Lausson, 2010). According to Benjamin Bayart (2009), the debate surrounding the HADOPI law contributed to politicizing a large number of 'mainstream' internet users for the very first time. It also paved the way for another central issue which dominated the policy agenda in subsequent years: that of Net neutrality—a central concept according to which telecom providers should not prioritize or block specific content or applications online (Marsden, 2010; Wu, 2010).

FDN was thus extremely active in fighting online censorship. In 2010-11, during the WikiLeaks Cablegate, FDN created a WikiLeaks mirror site to help circumvent censorship attempts and helped to channel donations to Julian Assange's organization to circumvent the banking blockade it was subjected to (Agence France-Presse, 2010; Champeau, 2012). During the Arab Spring, the organization set up modems and shared telephone numbers to allow Egyptian protesters to connect to the Internet through dial-up connections during the internet shutdown, also partnering with Reporters Without Borders to provide VPN services to political dissidents (Doucet, 2011; Luquin, 2011). All this attracted significant media coverage and helped publicize the role played by FDN in the debates surrounding digital rights.

This was the moment when Bayart, other FDN volunteers and a handful of other French non-profit access providers went on to motivate people across France to join and start building their own community networks. Rather than growing a single organization, the choice made was to 'swarm' in decentralized mode, creating many local non-profit organizations. Soon, in the context of the growing ability of the digital rights movement to frame these issues at the political level, Bayart's advocacy of non-profit internet access providers contributed to the creation of more than a dozen new initiatives across France, including amongst others, *Tetaneutral.net* (2010), *Lorraine Data Network* (2010) and *Sames Wireless* (2010). To coordinate these developments, share expertise and organize the movement's legal and political representation, an umbrella of non-profit organizations was also created: the *Fédération FDN* (FFDN), a "network of networks" now comprising about thirty community networks and 2500 member-subscribers. As a federation, FFDN and the various connected organizations were able to develop political and legal expertise within the existing political and legal institutions and educate the public on a range of issues, such as surveillance—a rising theme in the post-Snowden context (see Alloing, 2016).

Conclusion

While still providing internet access to many subscribers, FDN—and today FFDN—embarked on a major shift in the direction of political advocacy and remains a major player today in the field of French internet activism.

FDN's history suggests that community networks are crucial to understanding the broader history of communication networks, their uses and their politics. Our case study is one more indication of the central role of non-profit, alternative providers in popularizing access to the Internet in the early days when commercial provision had yet to go mainstream. These alternative providers and services acted as a key resource in the evolution of the early 1990s "enlightened amateurs," who sought to promote a "moral institution" of internet newcomers via *Netiquette* (Auray, 2012), to the more contemporary figure of the "critical Internet user," actively engaging with lawmakers and other power-holders while being able to point to these pockets of resistance alongside the key players (Paloque-Bergès, 2015; Pétin & Tréguer, 2018).

But FDN's history also shows that, as De Filippi and Tréguer (2015) have written, "[political] motives are not in and of themselves sufficient for the network to scale up beyond a restrained community of highly engaged individuals with strong ideological values" (p. 18). In order to survive and grow, "community networks must also provide a service that is considered at least as good and preferably better than that of mainstream ISPs" (p. 18). In the case of FDN, the adoption of ADSL technology in 2005 was certainly a turning point that allowed the association to survive and continue its political commitments.

Finally, this case study also contains interesting lessons for contemporary community networks, showing how they can act as a strategic locus for reinterpreting both ends of traditional "mediactivism" (Cardon & Granjon, 2013): the critique aiming to empower individuals and collectives to disseminate their own voices by mastering the roll-out of alternative networks, and the counter-hegemonic critique that tackles the structural issues, using these alternative networks as a symbolic resource to ward off forms of domination and collusion that divert telecommunications and media policies from the public interest.

If the history of the Internet remains largely to be written, this is all the more true of the history of community networks such as FDN and the broader history of internet rights activism. Our hope is that this article can provide a useful contribution to future comparative research that embraces the diversity of technological, political and national contexts.

zurück

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zurück

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Hacking Apartheid

Revolutionary Communication and the South African National Liberation Movement[1]

Sophie Toupin

Abstract

In the 1980s, South African freedom fighters created an encrypted communication system that allowed infiltrated activists on the ground to communicate secretly and transnationally with the senior leadership of the African National Congress (ANC) based in Lusaka, Zambia via London, UK. This encrypted communication system was set up as part of Operation Vula, an operation that aimed to launch a people's war and ultimately liberate South Africa from apartheid. While the successful deployment of an encrypted telematics system was remarkable at a time when the Internet as we know it today did not yet exist, the ANC already had a history of experimenting with and setting up different forms of communication systems. By mapping, documenting and elucidating the ways in which the encrypted communication system worked, this article explores one specific example of mediation via telematics technology in a liberation movement. Finally, I propose to explore this case study through the hacking apartheid concept, and ask how this concept enables us to think through hacking as a political, social and technical practice embedded in a national liberation movement.

Keywords: Hacking, Apartheid, Liberation Movements, Encryption, South Africa

It's early July 1990. The Durban Security Branch has just arrested two Umkhonto we Sizwe (MK)—the ANC's military wing—operatives in Durban, South Africa and found on them floppy disks containing a list of operatives' names, safe house locations and UK phone numbers, among many other things (Garrett & Edwards, 2007; Henderson, 1997; O'Malley, n.d.). By first arresting Mbuso Shabalala and Charles "Francis" Ndaba,[2]

1 I am grateful to Professor Darin Barney, Professor Gabriella Coleman and Professor Carry Rentschler for their generosity in advising me on the larger project associated with this article. This article is indebted to the freedom fighters who participated in Operation Vula and their allies. Finally, I would like to thank the peer reviewers for their feedback.

2 Shabalala and Ndaba were working underground for Operation Vula. After their arrest in

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the Security Branch had accidently discovered Operation Vula and an encrypted communication system whose aim was to dismantle the white supremacist regime in place since 1948. The computer diskettes and UK phone numbers were part of a sophisticated encrypted communication network developed by exiled South Africans Tim Jenkin and Ronnie Press[3] who were part of the African National Congress (ANC) Technical Committee (TC). The system had been up and running for two years (Jenkin, 1995) and enabled freedom fighters who were part of Operation Vula to communicate secretly and transnationally mainly between South Africa and Lusaka, Zambia via London, UK. Other links were also set up in Amsterdam (Netherlands), Alberta (Canada), Harare (Zimbabwe) and Paris (France).

This article will focus on the technological communication ingenuity and inventiveness of the South African national liberation movement. Mapping and documenting the prototyping of a variety of communication technologies built in, and for, conditions of oppression and scarcity is significant. It counters the belief that African liberation movements were devoid of early sophisticated technological experimentation and highlights the role played by anti-apartheid freedom fighters—one of whom is associated with the contemporary hacker movement—in bringing about freedom in South Africa. This article attempts to contribute to the history of digital media and communication studies generally and more specifically to the history of revolutionary communication by reflecting upon the South African liberation movement's communication and technological practices. This will involve presenting a brief overview of some of the communication tools experimented with by the national liberation movement including by the African National Congress (ANC), Umkhonto we Sizwe (MK)—the military wing of the ANC—and the South African Communist Party (SACP). Highlighting some of these projects situates the development of the encrypted communication system within a wider history of communication and technological development.

I will then touch on the concept of *hacking apartheid* as a way of understanding the development and use of this encrypted communication system. I will ask how this concept enables us to think through hacking as a political, social and technical practice embedded in a national liberation movement. Finally, I will call for further study of the experimentation, development and/or use of communication and technological systems by liberation movements, particularly in Latin America, Asia and Africa. Because of the nature of underground communication and the danger in

July 1990, they both disappeared. During the Truth and Reconciliation Commission, it was revealed that both operatives had been murdered.

3 Press passed away in 2009.

revealing its existence when in operation, it is usually only in hindsight that such systems can be revealed and that concept work can emerge from empirical projects.

Methodology

This article is based on mixed-methods, including a study of academic articles, published and unpublished autobiographies of South African freedom fighters, South African newspaper clippings of when Operation Vula was discovered in July 1990, published and unpublished messages exchanged through the system, video documentaries, interviews and archival work. One important archive I have examined for this research is the O'Malley archive kept by the Nelson Mandela Centre of Memory. This archive is of particular interest as it contains documents related to Operation Vula and the encrypted communication system (ECS). It was set up by Professor Padraig O'Malley who, between 1985 and 2005, conducted interviews with many key personalities who played an important part in South Africa's political history. The University of the Witwatersrand Historical Papers research archive was also important for this research as it consists of a number of documents and newspaper clips related to Operation Vula. The unpublished autobiographies of both Ronnie Press and Tim Jenkin were relevant sources which shed light on concealment and experimentation practices using heterogeneous communication tools.

Moreover, I have conducted interviews with the former freedom fighters who developed, used or operated the system. I interviewed Tim Jenkin many times (face-to-face and virtually) and kept up regular email contact with him. I also interviewed Lucia Raadschelders who was tasked with receiving and sending messages through the encrypted communication system from Lusaka, Zambia as well as Janet Love who was one of the operatives infiltrated in South Africa and who used the system to convey strategic information back to Zambia via London. I also interviewed Sathyandranath Ragunana 'Mac' Maharaj, Operation Vula's commander, in Durban. It was Mac who requested the ANC TC to find a way for freedom fighters to contact each other safely in urban environments (Jenkin, 1995), initiating further experimentation with encryption and programming that would eventually lead to the encrypted communication system. Additionally, I interviewed Helen and Rob Douglas, a Canadian couple who set up safe houses for Vula and facilitated the ECS operation.

This article draws on a previously published article entitled Gesturing Towards "Anti-Colonial Hacking" and its Infrastructure (Toupin, 2016). Finally, as this article is part of a larger research project, further

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interviews are being conducted in South Africa and more archival work is being examined in Cape Town, Durban, Johannesburg, Port Elizabeth and Pretoria.

A brief history of anti-apartheid technological experimentation

Operation Vula was launched in 1986 following decades of struggle that had failed to dismantle the oppressive white supremacist regime in place in South Africa since 1948 (Henderson, 1997; Motumi, 1994; Williams, 2000). The operation aimed to create the conditions for an armed insurrection—what was called a people's war. The aim of the operation was to facilitate direction of the struggle via the physical return of the ANC leadership to the country.

People's war was a frequent strategy among colonized or oppressed countries from the 1950s onwards in places such as Algeria, Cuba and Vietnam. In the context of South Africa, people's war was defined in the Green Book[4] as a "war in which a liberation army becomes rooted among the people who progressively participate actively in the armed struggle both politically and militarily, including the possibility of engaging in partial or general uprising" (O'Malley, 2008, p. 207).

As part of Operation Vula, an encrypted communication system was set up to facilitate secret and transnational communication within a small circle of people who were part of the national liberation movement. Vula—short for Vulindlela, meaning "open the road" in Zulu (Braam, 2004; Henderson, 1997)—was envisaged at a time when South Africa had seen increased levels of violence which many considered a context of near civil war (O'Malley, 2008). Operatives of the ANC, SACP and MK were routinely arrested, forced into exile, tortured and/or killed.

Prior to the setting up of the first functional version of the encrypted communication system as part of Operation Vula, the ANC, MK and SACP had a history of experimentation with different forms of concealment strategies and communication tools. In his unpublished autobiography, Jenkin (1992, p. 3) suggests that it was when the ANC was banned in the 1960 and many South African freedom fighters went into exile that "communication became a subject and practice in its own right." The ANC first set up an underground radio broadcast called Radio Freedom. While this underground radio station broadcast for a short while from South Africa,

4 The Green Book is also known as the Report of the Politico-Military Strategy Commission to the ANC National Executive Committee (ANC, 1979). It is in the Green Book that the concept of a people's war began to be part of ANC literature.

it soon stopped functioning when ANC leaders were arrested in the early 1960s. The radio broadcast resurfaced in 1969 in exile in Tanzania—where the Nyerere government gave it 15 minutes airtime per day—and in Zambia where the exiled ANC leaders were located, and then in other African countries (Mosia, Pinnock & Riddle, 1992).

When the ANC and other political formations were banned, cadres were sent to the Soviet Union and other destinations such as Cuba, East Germany and the Netherlands to learn radio engineering and methods of concealment, codes and cyphers (Jenkin, 1992; Mosia, Pinnock & Riddle, 1992; Naidoo, 2012). When they came back, cadres passed on their knowledge and trained those who needed it. Underground operatives sent to South Africa were soon cut off from the exiled leadership since transnational and secret communication using code books and invisible ink was very slow —it often took more than a month for a message to get through.

A less typical form of broadcasting was leaflet-bombs, which were used as a means to communicate revolutionary messages on printed leaflets—small detonators would launch pamphlets in the air in a crowded area—and were designed to wake South Africans up to the anti-apartheid cause (Edmunds, 2014; Jenkin, 1987). Primarily used in the 1970s, leaflet-bombs were meant to spread ANC material and news in a country where the ANC, MK and SACP and their messages were banned. Tim Jenkin (1987) was one of the main leaflet-bomb operatives, printing leaflets at night and "exploding" them in crowded areas during the day. Small detonations in public areas, and leaflets flying through the air, attracted attention, informed South Africans and defied apartheid censorship. However, after the Soweto uprising in 1976, Jenkin (1992, p.10) wrote that "it was our comms that prevented us from adapting to the new revolutionary situation and made us feel increasingly irrelevant." In referring to his leaflet bomb cell, Jenkin (1992) wrote: "Our incommunicado propaganda cell was like a factory without telephones to take the orders and operating in an environment without railways and roads to move the goods. Our hopelessly inadequate forms of contact were a rein holding us back." (p.10)

In 1978, Jenkin and his comrade were arrested for leaflet-bombs and sent to jail under terrorism charges. Before escaping by lock picking—it took Jenkin and two others one and a half years to craft a set of ten different wooden keys to escape—he returned to the ANC TC in London (Jenkin, 1987).

With his understanding of the challenges in the field, Jenkin joined the ANC technical committee with a mission to improve communications between the field and exiled leaderships. Jenkin and Press read books on programming and encryption, and went to technological trade fairs.

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The appeal of using electronic communication technologies can be explained by the distance separating anti-apartheid activists across many countries, the exiled status of the ANC leadership, the high levels of counter-intelligence infiltration within the movement and the burdensome nature of hand-written cryptography. Moreover, another goal of the encrypted communication system was to have Nelson Mandela use it during the negotiations over his liberation in the late 1980s (Edmunds, 2014; O'Malley, 2008; Mandela, 1995). An earlier attempt to make secret contact with Mandela through another device—the radio pen—is described in Ronnie Press's (1995) auto-biography: "[In 1970], I was asked to make a radio receiver that could be smuggled to Nelson Mandela on Robben Island. At that time they were denied all communication with the outside world even newspapers. The idea was to have the receiver in a pen and have one of the Red Cross visitors get it to Nelson. It worked well. The pen was sent down to Lusaka where it was tested. [...] Unfortunately our contact could not pass it to Nelson and the project failed." (p. 27)

The above brief and incomplete overview shows that efforts to design an encrypted communication system were just part of a history of experimentation with different forms of communication devices by the South African national liberation movement. The technical committee and its members were instrumental in crafting communication and technological devices that would foster the anti-apartheid cause. Not only did they experiment with heterogeneous forms of technologies and communication devices to adjust to realities on the ground, but they also read articles and books about technology, and relied on the expertise of other exile South Africans to further develop their skills. I will now turn to explaining how the earlier version of the encrypted communication system worked.

The how to of sending an encrypted message[5]

Documenting how the ECS worked is significant since it reveals how the technical and human infrastructure needed for such a system to operate worked. Top level South African cadres and their allies —many were Dutch and Canadians—were infiltrated on the ground through Operation Vula and used the ECS to communicate secretly (see fig. 1 below). These cadres and their allies were generally trained by Tim Jenkin in London, UK or Lusaka, Zambia. The training covered how to use laptop computers — the first time for many— encryption programmes and basic digital and physical

5 This section describing how the encrypted communication system worked draws heavily on an article I published in 2016 in the open access Journal of Peer Production entitled Gesturing Towards "Anti-colonial Hacking" and Its Infrastructure (Toupin, 2016).

security. Part of the equipment, including the floppy diskettes on which the encrypted system was found, were covertly delivered by a Dutch KLM flight attendant who regularly flew from Amsterdam to Johannesburg and doubled as an anti-apartheid activist (Braam, 2004).

If operatives wanted to send messages using laptop computers in Johannesburg, they first needed to encipher it using the encryption program, and then pass it on through the computer's serial port to an acoustic coupler modem. This converted the digital data into sound, and allowed the audio stream to be captured on a small cassette tape recorder. Operatives then took the tape recorder to either a public telephone or located a telephone in an office building and dialled Tim Jenkin in London. Dialling Jenkin's number automatically recorded the message on his answering machine. If Jenkin was travelling, instructions would be given to dial Ronnie Press's backup number, also in London. Jenkin's and Press's flats were connected by an electronic Bulletin Board System (BBS) with a backup radio link. The tape recording was played through a small speaker into the telephone mouthpiece. Audio messages were stored on the London 'receive' answering machine and Jenkin (or Press) would then reverse the process, playing the received audio messages back through a similar acoustic modem attached to their computers, thus converting it back to a digital file which would be deciphered using a matching floppy diskette. Deciphered messages then appeared as plaintext on the computer screen, and could be printed for archiving, stored via another encryption programme or forwarded. The London operators would analyse each message to determine which items were to be passed on to Lusaka, which were for other destinations and which could be dealt with by ANC operatives based in London.

When messages needed to be sent to South Africa from London, the operatives who the messages were for would be paged by telephone and given a code indicating the number of messages they would be receiving. They would then go to a telephone and dial a different number in London, connected to a 'send' answering machine. The messages to be received were played as outgoing messages by the answering machine and recorded by operatives onto the same small cassette tape recorder by placing a special microphone on the phone earpiece. The recorded messages would then be taken home, where they could be played back into the laptop via the acoustic modem and deciphered as described above.

Initially, the arrangement in Lusaka worked in much the same way—only without the need for public telephones. An operative —Lucia, a Dutch woman, operated the Lusaka station for almost two years —she received enciphered messages, deciphered them, printed them out at her office and couriered them to ANC president Olivier Tambo and other senior

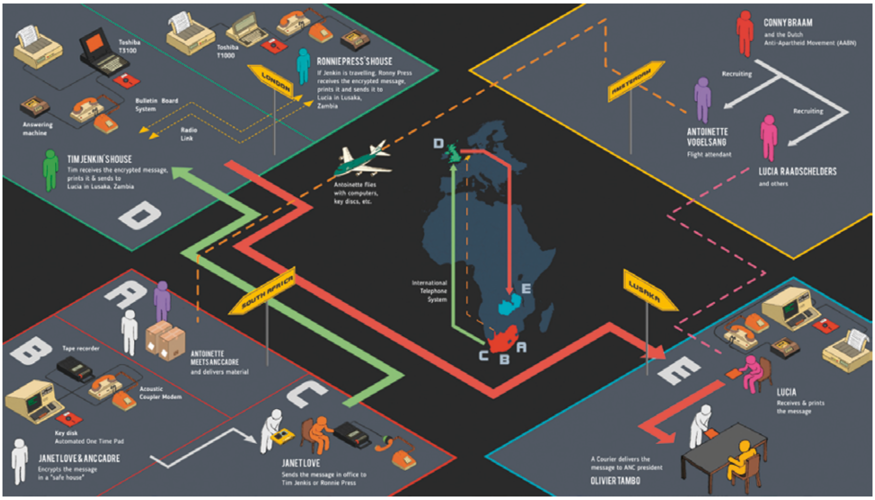

Fig. 1: Infographic: Ariel Acevedo and Sophie Toupin. CC BY-NC-SA. Simplified infographic showing how the encrypted communication system worked.

Operation Vula operatives. Outgoing messages from Zambia were likewise left on the London 'receive' answering machine. Later, a telematic set up in London allowed users to dial into a dedicated computer system used for both depositing and receiving messages.

The ECS was fully operational from July 1988 until June 1991. On the South African end, only a few top-level cadres involved in Operation Vula used the network directly, while other operatives performed more minor roles, such as preparing safe houses or relaying messages over public telephones. Other encrypted communication links facilitated contact with the Netherlands, Canada and other locations in the UK, among others. In July 1990, the ECS was accidentally discovered and, as a result, many of the Vula operatives in South Africa were arrested. This was the moment that the South African authorities became aware of the technological sophistication of the ECS designed by the ANC technical committee. After the bust, Jenkin changed the system's encryption keys—a move that enabled operations to continue for almost another whole year. When the arrested Operation Vula cadres were granted amnesties in June 1991 and negotiations with the South African government were at an advanced stage—Mandela had already been released—the ECS slowly wound down. Operation Vula had largely ceased and secret communication was no longer seen as a priority.

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Hacking apartheid

The concept of *hacking apartheid* might help illuminate the practice described above, one which has largely been invisible in the history of hacker movements. In this short section, I will attempt to shed some light on this signifier or category and enquire into the extent to which this concept enables us to think through hacking as a practice in a national liberation movement. Also, I will link up this practice to another form of hacking which took place in South Africa, this time not 'hacking' the apartheid regime via the creation of an alternative infrastructure but attempting to disrupt the first democratic elections in 1994. Finally, I will touch on what this concept of hacking apartheid might accomplish.

In the 1970s and 1980s, the term "hacking" was not well known beyond a very specific circle. This does not mean, however, that the terminology may not be useful with the benefit of hindsight. Hacking can loosely be defined as a practice that involves tinkering shrewdly with a range of technologies. Gabriella Coleman (2014a, p.1) has defined a hacker as "a technologist with a penchant for computing and a hack is a clever technical solution arrived at through non-obvious means." While Tim Jenkin did not see himself as hacking during the Vula years, nor when he lock picked his way out of prison, he now identifies as a hacker, but a good one! Far from fearing technologies, hackers attempt to understand how they work for various purposes be they a hobbyist passion, technical curiosity or, in the case of the encrypted communication system, to evade state surveillance by building an alternative infrastructure and, ultimately, achieve liberation. This practice echoes the book Hacking Europe, where Caroline Nevejan and Alexander Badenoch (2014, p. 199) argue that "[b]y understanding rather than fearing the tools of computers, hackers could subvert the process by appropriating them for their own goals." Moreover, hacking apartheid resonates with the book Resistance, Liberation Technology and Human Rights in the Digital Age (Ziccardi, 2013) where hacking is understood as a form of liberation technology in the contemporary era and across countries. The ECS case study expands the repertoire of hacking as a liberation or revolutionary technology by showing how such practice was implemented in a situation of significant oppression during a struggle for emancipation.

While many politically oriented hackers in the West have tended to use hacking to uphold civil liberties such as free speech, privacy, and access (Coleman, 2014b), freedom fighters in South Africa used politically-oriented hacking practices to dismantle the white supremacist regime. They repurposed various forms of technology to organize transnationally and secretly, thereby attempting to evade the South African regime's surveillance apparatus. What they ended up building was an alternative communication infrastructure, one of a number of responses to apartheid's technological infrastructure. For some time, the South African apartheid regime had been involved in technological infrastructural political projects designed to oppress, differentiate the country from other African nations and demonstrate its modernity. As a case in point, the regime set up a passbook system (Bowker & Star, 2000) which aimed to track down and fingerprint all non-white individuals. Only in the 1980s was fingerprinting extended to white people following a series of sabotage attacks on oil installations (SASOL plants in particular) by white members of MK (Breckenridge, 2014). The aim of the passbook system was "to stabilise a specifically racial personal identity around a document coupled with a biometrically indexed database" (Edwards & Hecht, 2010, p. 625), to control the movements of the black population. These techno-political projects were presented as examples of "industrial development"—a rhetoric that masked its underlying racial oppression (Hecht, 2012). All the while, the regime was at work developing and using computer systems to automate or computerize apartheid's processes (NARMIC/American Friends Service Committee, 1982; Komitee Zuidelijk Afrika, 1990).

The ANC technical committee's freedom fighters had much in common with social justice oriented hackers. Firstly, they shared a love of science and technology (Press, 1995). The drive to think with technology to find ways of fighting injustice is paramount for social justice oriented hackers. Secondly, the two main developers of the ECS were part of a socially privileged group of actors who were male, white and in exile in London when they developed the system. They used these privileges (whiteness, skills, know-how and access to technologies, among others) in their struggle for a better world. Thirdly, whether in the global North or South, hackers play a geopolitical role (Coleman, 2017). The threat represented at the geopolitical level by hackers is prevalent today. In South Africa, it can be illustrated by a US State Department cable sent from the American embassy in Pretoria to Washington in July 1990 when Operation Vula was discovered. The cable reads: "Despite Mandela's disclaimers, the available evidence shows that an ANC underground structure is operating in South Africa, that it is dominated by communist party members and that it is well-armed and well-organized. It is also computerized" (O'Malley, n.d., p.n.d.).

While a hacker group such as Telecomix[6] has much in common with Operation Vula's ECS, the context and conditions in which hacking was deployed in the anti-apartheid era differs. An apartheid-like situation is Palestinian resistance through hacking, including sabotaging Israeli web-

6 When the Mubarak Regime cut off access to the Internet in 2011, a group of hackers called Telecomix acted together with Egyptians and helped to circumvent the blockage (Dahlberg-Grundberg, 2016).

sites and circumventing censorship (Skare, 2016) which also has similarities with the ECS though it is more about disruption than building an alternative tech infrastructure. Using the concept of hacking apartheid is helpful when considering a communication and technical infrastructural response to the regime's oppression.

Looking at the practice of hacking within the national liberation movement builds on the wider ranging ideas of Jean Comaroff and John Comaroff (2012) in their book Theory for the South: Or, is Euro-America Evolving Toward Africa. In their book, they argue that it is the "Global South that affords privileged insights in the working of the world at large" (Comaroff & Comaroff, 2012, p. 1). Their argument not only shifts our centre of gravity toward the global South and Africa in particular, but also aims to highlight the fact that extreme forms of capitalism and (neo) colonialism have led to both frightening configurations and innovative counter political action.

The above case study highlights a type of hacking for national liberation whereas below I will briefly tell the story of a type of white supremacist hacking, which happened during the first democratic election in South Africa. Peter Harris (2011) documents this instance of hacking in Birth: The Conspiracy to Stop the '94 Election'. In this book, he tells the story of how right-wing hacker(s) attempted to break into the electronic counting system during the 1994 South African election. Before Harris and his team at the election commission discovered it, the hacker(s) successfully broke into the voting system to increase the votes of two white supremacist parties and one fierce ANC opponent— the National Party, the Freedom Front and the Inkatha Freedom Party. However, the election commission discovered the hack when it happened and thereby minimized its impact and ensured a democratic process. What this brief example illustrates is that computer hacking did exist in South Africa in the 80s and 90s, and it was used by people and movements to further their political vision both pro- and anti-colonialism, pro- and anti-fascism, pro- and anti-racism.

The final question I would like briefly to explore is what the concept of hacking apartheid can accomplish? Firstly, it enables us to understand hacking as performative; the setting up of a complex communication system with a clear anti-apartheid stance aiming at freedom and equality. The system configured particular forms of communication devices specifically for the purpose of facilitating emancipation at a time when liberation from apartheid seemed beyond reach. This was in stark contrast with both the right wing form of hacking exemplified above and the apartheid state which had initiated techno-political infrastructural "development" projects (such as mining, nuclear energy, a biometric system and other surveillance mechanisms).

The use of the word performative in this context is inspired by Judith Butler (2004) who, in her book Undoing Gender, gives the example of black South Africans under apartheid who turned up at polling stations to vote even if they did not have the right to do so. They performatively invoked the right to vote with no prior legal authorization (Butler, 2004). This, Butler argues, was an innovative practice of some value as part of a process whose aim was to create a less violent and exclusive future, a future that laid claim to universality and justice just as it sought to counter racism and violence (Butler, 2004).

Secondly, it allows hacking to be viewed as a highly political and intentional practice within a specific white supremacist context. When hackers design systems or disrupt or reinvent existing ones they have aims in mind. Stressing their agency is paramount, especially in view of the fact that the reasons behind their actions were that non-whites had long been denied such agency under apartheid. However, as crafty as hackers might be, we should not underestimate the confederation of human and non-human assemblage (Latour, 1991; Mitchell, 2002). Mitchell (2002, p. 34) reminds us that "human agency and intention are partial and incomplete products." No individuals really master all the elements, technological or otherwise, and the connections between them. This means that to understand how power works holistically, human agency and intentionality in and of themselves are insufficient.

The practice of hacking apartheid was deployed in a context of violence and injustice. It was one of a range of responses to an infrastructure of violence and injustice. Therefore it seems to have been ephemeral, coming and going as needed. While I use the term ephemeral here, I am not situating the practice of hacking apartheid as a heroic moment in the past and therefore ephemeral and vain, but rather considering it as embedded in past and present everyday forms of resistance. This view is informed by Frederick Cooper (2005, p. 25) who shies away from a disillusioned approach which reifies an understanding of an "atemporal modern colonialism." Understanding hacking apartheid in this way enables the concept to be supported and cultivated in the present.

The deployment of hacking apartheid is also different from state or corporate sponsored technologies whose purpose is frequently control, measurement and/or surveillance. In the case of South Africa, both Keith Breckenridge (2014) and Antina von Schnitzler (2016) have demonstrated how state sponsored technologies travelled from and even expanded out of the apartheid era into the democratic era. Both biometric registration systems and pre-paid meters for water or electricity consumption have been implemented. While it has been well documented that these techno-political systems have travelled from one era to the other, I wonder the extent to which hacking against injustice has also travelled from the apartheid era into the democratic era in South Africa. While such practices do not seem to produce lasting techno-political infrastructures, the extent to which continuities in hacking practices from pre- to post-apartheid eras exists requires examination. At this particular juncture, what needs to be further examined is the relationship between current hacking practices in South Africa and the encrypted communication system developed during the national liberation movement. Are there perhaps forms of continuities (and discontinuities) with past and current hacking practices in South Africa?

Conclusion

This article highlighted some of the inventiveness of the South African national liberation movement from a communication perspective by exploring one main case study of the development and use of an encrypted communication network during the 1980s. It then examined the concept of hacking apartheid as a way with which to understand this system and touch on what this concept might mean.

This article makes a twofold contribution. Firstly, it recognizes that the South African national liberation movement was technologically sophisticated. It experimented with heterogeneous communication devices with the goal of securing and increasing the speed of communication between freedom fighters located across borders. What still needs to be examined, however, is whether this case study was a precursor within national liberation struggles. Or were other case studies of the development of alternative technological infrastructures using computer encrypted communication created by other national liberation movements? More work is needed to answer these questions. Secondly, this article builds on a previously published article (Toupin, 2016) and continues to explore the way in which this practice of designing an alternative technological infrastructure is linked to the history of the hacker movement and hacker practices.

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Computer Networks on Copper Cables

From 'Promises to the Public' to 'Profits for Providers'

Christian Henrich-Franke

Abstract

The history of computing often comes across as a history of fundamental social and economic transformation which culminated in the digital era. The literature usually presents computers and digital networks as innovations of an epoch-making character. The 1970s and 1980s, in particular, are judged to have been a period in which highly innovative engineers opened the way to the digital future. Packet-switching and protocols like X25 enabled electronic data interchange between computers and launched digital communication's triumphal march. Such stories often omit the role played by older technologies, which were hidden in a physical infrastructure that was underground. Computers, especially household computers, were interconnected by the physical infrastructure of the telephone network which, in the 1970s and 1980s, was often decades old. The double-core copper cables which were the backbone of telephone networks were the core element in the early 'information highways' in large public digital communication networks.

The aim of this paper is to discuss the role played by public telephone network twisted pair copper cable infrastructures in the history of large scale data communication networks for mass users in Europe. The paper raises a number of questions: what was the extent of copper cables' impact on the emergence of data and computer networks for the general public? Why was an old copper cable infrastructure chosen as the basis for such networks? How were investments in infrastructure justified? What role did 'analogue technologies' play in the transformation of societies and economies into the digital era?

I would argue that copper cables, and twisted pair cables in particular, were chosen as the basis for data networks for many and varying reasons. In the 1980s they constituted a promise to the public, which fully accorded with monopoly obligations. The telephone network was the only network capable of providing nationwide coverage within a short time frame and at acceptable costs for users. After the telecommunication markets were privatized and the internet had triumphed this changed completely. From then on copper cables on the 'last mile' meant profits for providers. The invention of DSL technologies allowed for high transmission rates without investment in fibre optic cables on

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> this part of the network being required. Private companies and stake holders preferred to make profits from an old but inexpensive copper network rather than investing in expensive fibre optic cables. In the long run this turned out to be an obstacle to high speed connections as transmission rates are still very low as compared with those of networks consisting solely of fibre-optic cables.

The history of computing is often told as a story of fundamental social and economic transformation. The literature usually presents computers and digital networks as innovations of an epoch-making character, impacting on people's everyday lives (Balbi & Magaudda, 2018; O'Regan, 2016; Haigh, 2016; Albers, 2014; Ceruzzi, 2003; Abbate, 2000). The 1970s and 1980s, in particular, are judged to have been a period in which highly innovative engineers opened the way to the digital future (Castells, 2002). Data processing, packet-switching and protocols like X.25 enabled electronic data interchange between computers to take place and launched digital communication's triumphal march.[1] Such stories often omit the role of 'old' technologies, which were hidden in a physical infrastructure that was underground. This is unfortunate as the impact of this infrastructure on computer networks' transmission capacities and thus performance was highly significant. Household computers in particular were connected up by the telephone network's physical infrastructure which did not change in the 1970s and 1980s. The twisted pair copper cables which were the backbone of telephone networks were the core element in early 'information highways' in large public digital communication networks. Therefore, the roots of computer network development lie in the development of computers as well as in the development of the network infrastructures they use.

The aim of this paper is to discuss the role played by twisted pair copper cable infrastructures in the history of large scale mass user data communication networks in Europe. The focus is on the public telephone network because this was the most important mass communication network for the wider public. This paper zooms in on the household and its computer network connectedness. Of course, there were also other networks too, which served particular companies or paying customers (in large cities). These networks, however, will only be mentioned in passing.

The paper will raise a number of questions: what was the extent of copper cables' impact on the emergence of data and computer networks for the general public? Why was an old copper cable infrastructure chosen as the basis for such networks? How was investment in infrastructure

1 See, for example: Thematic Focus: Fundaments of Digitization, in: Media in Action, Issue 01/2017 (www001.zimt.uni-siegen.de/ojs/index.php/mia/issue/view/1).

justified? What role did 'analogue technologies' play in the social and economic transformation to the digital era?

To answer these questions this paper will begin by considering some of the basic characteristics of telephone networks and then move on to a discussion of what has determined and developed (trans-border) telephone networks from their 1970s origins to their digitization. Thirdly, the emergence of mass user data communication networks in the 1980s and their subsequent transmission capacity increases will be discussed. Finally, conclusions will be drawn.

It must be stressed that telephone networks for computer communication developed variously within Europe, however, within the same model (Noam, 2002). Here, my main reference is the German example because Germany played an important role in the development of data communication networks in Europe and even today its share of twisted pair copper cables in the overall European network is still the highest. Germany has the largest net technologies market in Europe and was the driving force behind the Integrated Services Digital Network (ISDN), which has played a key role in European development.

Some basic telephone network technical and institutional characteristics

What are the components of a telephone network? In terms of material parts, telephone networks consist of four major components: cables (local loops and trunk lines), switches, amplifiers and end devices. Of course, cables were supplemented by radio links as part of the overall network. In this paper, however, the focus is on the cables, which were the backbone of telephone networks.

National telephone networks usually consist of various network levels. In Germany, for example, the national network was made up of four levels in the 1970s: a supra-regional network, a medium regional level, a lower regional network and a local network. For users these four levels are a unit. Technically speaking, however, they are separate entities and switching between the various network levels is a crucial factor in transmissions—especially when different types of cables are involved. Significantly, it is the technically weakest link in the networks which determines transmission rates for end user (Hars, 1989).

Replacing a widely ramified network is a difficult matter and one which requires significant investment costs. Switches and amplifier relays have to be replaced as do the various cables. The bulk of this infrastructure is generally underground and this makes it even more difficult and

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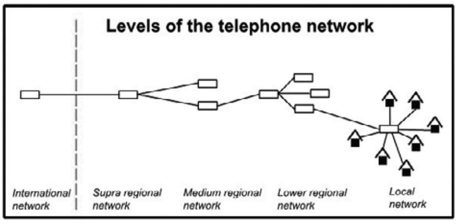

Graph 1: The various levels of a telephone network.

expensive to install. In particular, in densely populated areas, road surfaces needed to be dug up and lines into numerous households replaced. The 'last mile'—the distance between the last service area interface and the household—is often the weak link in a mass user network. Here, of course, the investment involved is much more critical as the cables etc. are much more ramified, much higher in number and frequently underneath a quantity of urban infrastructure and buildings. By contrast long distance regional network lines are multi-fibre cables on which a large number of transmissions are channelled via the same cable. These investment costs are labelled 'sunk costs' because they require large scale investments and lengthy time frames before investments pay off. Economically speaking, long term use of such networks is desirable for telecommunication service providers. Rapid technical development is usually regarded as a threat to sunk costs (Russel, 2018).

Telephone networks on copper cables, like infrastructure in general, are prone to path dependencies. Once a technical path and its system characteristics has been chosen, it is difficult to change track. Components need to be (backwards) compatible with other network elements—and also with the numerous end devices (Ambrosius, 2015).

Technology cannot alone tell the (home) computer networks on copper cables story. The market structure for telecommunication services in the 1970s was equally important. Across Europe national monopoly service providers operated all telecommunication networks but did so, however, under various types of public service rule constraints. In Germany, for example, the Bundespost owned all the equipment including home telephones themselves which were hired from the monopoly firm until the 1980s. As a public service institution the Bundespost was subject to legal restrictions in its investment decisions and technological policies. Statutory provisions required the Bundespost not to invest in risk capital and it was obliged to offer the same type of service for the same price nation-wide within the telephone network. Moreover, it had to offer reduced price services to the economically disadvantaged (Staab, 1980). Consequently, European monopoly firms in the telecommunication sector

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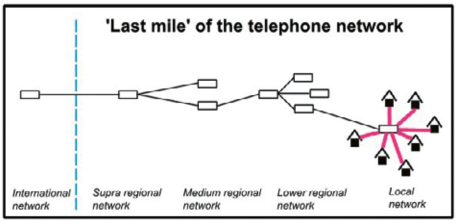
Graph 2: The 'last mile' of a telephone network.



had to 'think technology', technical change and technical innovations in terms of nation-wide function and affordability (Noam, 1992). Improving the existing infrastructure technically and economically was the paramount objective as compared to the introduction of new services and products. This was still the case when digital transmissions technologies entered the telecommunication equipment market in the 1970s and 1980s. This 'thinking technology' logic is the key to understanding developments surrounding copper cables. In this respect Europe differed remarkably from private service providers in the US, where 'public service' has never been such a powerful concept.

Telephone networks on copper cables

The origins and development of telephone networks

Telephone networks were first set up in the late 19th century as small local networks with limited numbers of subscribers. Cables were generally single line copper cables with a limited capacity. The interwar period saw the next step in network development, when long-distance cables were installed to connect up European regions and nations (Wheen, 2011). It was in the 1950s and 1960s, then, that the true breakthrough in the creation of wide ranging telephone networks took place across Europe. Automatic switching, duplex use of cables and other technical innovations increased networks' efficiency, reduced costs and thus enabled more and more people to be connected to and use telephone networks. Subscriber numbers exploded, reaching close to nation-wide coverage. Almost all households were connected to it, wherever they were (Ahr, 2013).

In the 1950s and 1960s the various telephone network lines were made up of twisted pair copper cables in the lower regional and local networks and coaxial cables in the upper regional and long distance networks. Transmissions were analogue and thus the switches and amplifiers processing analogue transmissions used in the networks were also analogue.

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It was a limited capacity system, sufficient for voice transmission but capable of hosting only very limited data communication volume at a low capacity (Chapuis & Joel, 1990).

Digitization of the telephone network

The introduction of the F1 transmission system by the Bell laboratories in 1962 was a milestone in the subsequent development of data communication networks on telephone lines. The F1 system allowed twisted pair copper cables to be used for digital transmissions for the first time and, therefore, took an important step closer to mass user data communication. For the transmission of signals, Pulse-Code-Modulation replaced frequency division multiplexing on analogue lines. The new technology promised numerous advantages: it was less prone to interference and was space-saving and labor intensive, making for faster link connections, increased capacities and thus reduced telephone network running costs by up to approximately 40%. Even better, only the switches needed to be renewed (Elias, 1977). 'Analogue technologies' like numerous telephones could be used even under digital transmission conditions. Analogue signals were simply switched to digital ones. Therefore, in the 1970s many European post and telecommunication administrations decided to digitize their telephone networks. At that time, however, hardly anyone had digital data communication networks in the back of their minds.[2]

Alongside switch digitization, a revolution in cable technology was also looming in the 1970s, with fibre optic cables containing a number of optical fibres capable of carrying light. The first generation of these was no better than copper cables in capacity terms (this was only the case later, in the 1980s) but reduced the space requirements and costs involved in running and maintaining a network. Fibre-optic cables promised economic efficiency and the European PTT administrations therefore began replacing copper cables in long-distance lines in the late 1970s. Europe's upper and the lower regional lines followed, in the 1980s and 1990s. In the local networks, however, many twisted pair copper cable lines remained—in particular the last part connecting up individual households. Renewing local networks was simply too expensive at that time.

To sum up, in the 1970s the European monopoly administrations decided to digitize their telephone networks solely for economic reasons. This decreased telephone service costs and was a promise to the public. Increasing the network's efficiency also fully complied with monopoly firm obligations.

2 See: CCITT documents, ITU archives (Geneva).

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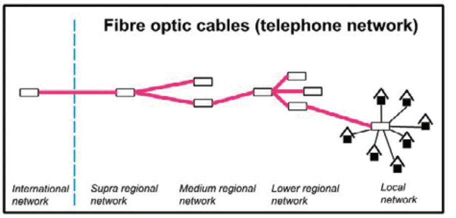
Graph 3: Fibre optics in the telephone network (1990s).



National telecommunication policies and data networks on copper cables

Closed data communication networks

When data communication network digitization was decided upon, in particular for text-messaging, data communication networks had co-existed alongside telephone networks for decades. Telex networks had been operational since the 1930s, when the German Reichspost had introduced the service, however telex had only a limited number of subscribers—mostly companies and local authorities. After WWII the service spread across Europe and the world for text-message transmission. Capable of delivering information at a rate of 50 bauds, the telex system later replaced 19th century telegraph systems. It was capable of transmitting 66 words per minute and was, at least up to 1970s, superior to any form of telephone network text sending system. Telex was not a nationwide service for end users however. It did not connect up private households but rather large companies and local authorities.

From the mid-1960s and early 1970s onwards data communication network development accelerated within two separate contexts. On the one hand, there were closed data communication networks for computers like ARPANET, which allowed for high transmission rates among a limited number of computers (Abbate, 2000; Schmitt, 2016). On the other hand, the national telecommunication administrations, their industries and a number of computer companies developed publicly available data networks under monopoly service conditions. These networks generally integrated older text messages forms and new data transmissions. Stepwise networks like Datex-L-net, which used the physical infrastructure of the former telex network and was thus separate from the telephone network, increased their transmission rates and converted to packet switching on the basis of the famous X.25 protocol. They enabled telex machines or memory typewriters to communicate with other forms of teleprinters, however international services were often impossible until 1984 (Hillebrand, 1978). A new development was mixed private and public systems like e-post or telefax which still used the old telex network at the outset but were subsequently made available on the public telephone network. In the 1980s numbers of integrated data networks offering even better services, up to 64kb/sec, exploded. Fibre optic cables allowed for broadband television and radio program transmission and broadband cable-TV networks emerged in the 1980s and 1990s using coaxial copper cables, especially in the BENELUX countries, which were transformed into broadband service networks in the long run.

Numerous data communication services appeared in the 1970s and 1980s whose aim was to improve office communication without prioritizing data communication for a mass audience. Some of these existed side by side, others competed with one other. They all had different technical characteristics and required different switches, cables and protocols. The majority were still closed networks that were not designed for mass use (Lernevall & Akeson, 1997).

Open data communication for the general public in the public telephone network

The early 1980s was a critical juncture for the future development of telecommunication networks in general and computer networks for mass use in particular. Two formerly separate developments—computer networks and telecommunication networks—now linked up. The key issue was the future development of networks for data communication. Should these networks be nationwide and open or closed networks for specific uses and users? Should there be plural networks for individual services or a limited number of networks integrating the various services? The answers to these questions were the basis for many future technological development decisions.

One of the key players deciding on such matters in Europe were the national telecommunication monopoly firms. Although deregulation and privatization of the telecommunication sector was already on the horizon, the monopoly firms were still a decisive power as they owned telecommunication networks and provided services on them (Heuermann, 1984). It was not until 1987 that the EC Commission put the topic on the agenda when it issued a green paper on telecommunication markets (Ungerer, 2013). And it still had to 'think technology' in monopoly firms' terms, particularly regarding nation-wide services and equal prices. Therefore, the existing telephone network—the only one with nation-wide coverage—had to be the starting point for further consideration and research. The telephone network lent itself to an even greater extent to becoming the basis for mass data communication as its digitization was already under way. Twisted pair copper cables in the local networks thereby automatically became a key element in the data communication network future.

A number of services for data communication were already established or in the planning phase at this time and involved using the public telephone network as a carrier system. In the late 1970s the first telefax systems started operating as a picture and drawing transmission service. Services like 'Bildschirmtext' (BTX) and 'Médium interactif par numérisation d'information téléfonique' (Minitel) were additional data transmission options from the 1980s onwards, providing for simple services such as ticket purchase, message boards, etc. (Schafer & Thierry, 2017). They connected up household end devices with low transmission rates for digital data communication. The German BTX, for example, had 1200 Kbit download and 75 Kbit upload rates. These networks and services were—in the traditional European telecommunication technology design context—solely planned as national networks with limited cross-border facilities. New service subscriber numbers varied considerably. In Germany, for example, the interactive videotext system BTX had approximately 60,000 users in 1986, whereas the Bundespost originally calculated one million. In France, however, Minitel had one million subscribers in 1985 and this success led to it remaining in service even after the turn of the millennium. At the same time, when new data communication systems were developed by the national telecommunication administrations (and their industries) data communication using modems in the telephone network increased, especially with the dissemination of home computers such as Commodore C64 (Driscoll, 2014).

Many modem users circumvented the Bundespost monopoly over public telephone network transmissions and connected up their computers illicitly (Röhr, 2017). All these digital data communication services worked on low transmission rates, however, enabling households to connect to data networks on twisted pair copper cables and introducing a client-server model for home computer use. Equally important is the fact that data communication via computers (or comparable devices) became increasingly usual. TV teletexts were an example and brought data communication to the general public. People got used to home data communication.

In the 1980s it became clear that any future data communication market developments would depend on a more effective infrastructure enabling higher transmissions rates. To provide an increasing number of users with better services the telecommunication administrations worked hard to increase telephone network transmission capacity to 64 Kbit or 144 Kbit. Nevertheless, in the 1980s the telecommunication administrations were convinced that telephone communications would long remain the most important household service whereas telefax and computer connections would remain subordinate (Rosenbrock, 1984). Even the most

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Table 1: Number of telephones in Europe (1978)

Europe	155,961,700
(West) Germany	22,931,683
Great Britain	23,182,239
France	17,518,813
Italy	16,125,204

enthusiastic exponents of digital data communication did not foresee a dramatic increase in the use of data networks by the wider public. For this reason, too, the twisted pair copper cables in the local networks were still regarded as a sustainable technology prior to 2000. In 1984, 82% of total telecommunication sector revenues came from phone calls. This led to the German post and telecommunication administration, for example, deciding to develop an Integrated Services Digital Network (ISDN) by replacing an analogue infrastructure stepwise with a digital one in 1987. ISDN continued and accelerated the ongoing process of digitizing the public telephone network. It promised public use of data communication networks for a variety of services to the general public. Nationwide end users were to be able to use their home computers for data communication purposes. No one anticipated the mass connectivity with home computers to the Internet over the same physical telephone network infrastructure which came to fruition in the 1990s (Irmer, 1982). Quite the contrary, in 1987 the German post and telecommunication administration estimated a maximum of two million households using data communication services at low transmission rates in the ISDN network (Schön, 1986).

To sum up, the 1980s were in many regards crucial for computer networks on copper cables as the monopoly telecommunication firms enabled households to connect up to data communication networks nationwide and get used to data communication.

High-speed on copper: households and the Internet

The 1990s began with the deregulation of telecommunication monopolies across Europe. National administrations—then the largest state owned companies across Europe—were privatized. Completely new legislation was subsequently introduced by the European Community and national governments (Bartosch & Braun, 2009). Instead of 'thinking technology' in monopoly terms, private operators now had to think profit-oriented.

This also meant attempting to avoid investing in cable infrastructure, for example, by rapidly introducing fibre optic or high capacity coaxial cables into local networks. They prioritized cheaper technologies to increase transmission rates, necessary to households in the internet age. Replacing twisted pair copper cables with fibre optics in the 'last mile' was downgraded as a priority in the late 1990s and early 2000s as private providers prioritized profits (Schneider, 2001). They were backed by the emergence of asymmetrical subscribers, which based wide-band signals above the analogue based signals and thus allowed for a breakthrough of transmission rates on twisted pair copper cables. Different standards within the Digital Subscriber Line (DSL) services subsequently allowed for ever higher transmission rates. When DSL technology prices dramatically declined in the early 2000s, it turned out to be a further obstacle to the installation of fibre optic cables on the 'last mile' (Golden, 2007). Nevertheless, in actual fact, twisted pair copper cables are technically limited as the pairs disturb one another, thus limiting potential transmission capacities. Without a new cable infrastructure, the different modulation and compression modes are simply second best solutions. DSL technologies cannot replace investment in fibre optic cable infrastructure if high transmission rates are to be made possible. The 'last mile' on copper remains a critical section of the network, although VDSL promised higher transmission rates up to 100 Mbit. Telecommunication providers and regulators in countries like Germany—which relied on copper cables for some time and did not invest in fibre optic technology at the local network level—lag behind in average transmission rates for household data communication (Bluschke, 2007).

Conclusion

Copper cables, and twisted pair cables in particular, were chosen as the basis for data networks for many and varying reasons. In the 1980s they were a promise to the public which fully accorded with monopoly obligations. The telephone network was the only network capable of nationwide coverage within a short time frame and at affordable user costs. After the telecommunication markets were privatized and the Internet triumphed, this changed completely. From then on copper cables on the 'last mile' promised profits for providers. The invention of DSL technologies allowed for high transmission rates without the need for investment in fibre optic cables on the part of the networks. Private companies and stake holders preferred to make profits with an old but inexpensive copper network rather than investing in expensive fibre optic cables. In the long run this turned out to be an obstacle to high speed connections as the transmission rates are still very low as compared with a network consisting solely of fibre-optic cables.

The advantages generated by new modulation and data compression modes enabled households to be supplied with ever higher transmissions rates and access to digital communication facilities. However, they cannot outweigh the disadvantages of a cable infrastructure that is still based on twisted pair copper cables, some of which are 50-60 years old, rather than fibre optic or high capacity coaxial cables.

Twisted pair copper cables may have survived social and economic transformation because they were not an 'analogue technology' but rather a technology from 'analogue times', a compromise solution in the early phase of the shift to the digital era. Their importance lay in their ability to disseminate data communication to larger parts of society and introduce a wider public to data communication.

Finally, copper cables, and twisted pair cables in particular, are a key element in the history of computing. The Internet was only able to develop into a mass home user network because technical innovations made the use of copper cables for advanced data communication possible. Without digital transmissions over 'analogue era' cables the Internet would either not have turned into a key technology for society as a whole or it would have taken much longer. Nevertheless, even if (twisted pair) copper cables can be used for high transmission rates, they were superior to fibre optics and thus limited potential transmission capacities. Despite being a key technology in the rapid dissemination of digital mass communication, copper cables have often been overlooked in historical research. Perhaps this is because they are so invisible.

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The Dawn of the Internet in Brazil[1]

Marcelo Savio Carvalho, Henrique Luiz Cukierman

Abstract

This paper describes the implantation of the Internet in Brazil as a sociotechnical construction, i. e., as the result of a set of regulatory and governmental acts, academic initiatives, strategic investments of the government and its agents, market actions of telecommunication companies and efforts of the third sector. It initiates with a historical account of computer networks, starting from their roots in the United States in the 60s, examines some issues of the networking standards movements, describes a variety of networking initiatives in Brazil and reaches the deployment of the commercial Internet in the mid-90s, culminating in the institution of governance mechanisms of this network in the country.

The implantation of the Internet, as to any technological artifact, is an inseparable entanglement of science, technology and society. So in order to understand it, one must go beyond technicalities, and observe the recruitment of numerous allies and their involvement in different scenarios that ended by giving the form and robustness materialized in the way we see it today, but which is still partial, unfinished and constantly changing.

In order to highlight the local specificities of the implantation process of the Internet in Brazil, the present text goes through a series of facts and artifacts that, along the last quarter of the 20th Century, shaped the trajectory of the Internet in the country.

The text starts with the emergence of data communication networks and services in the early 80s, as well as the information control policies supported by national security concerns, which were highly important

1 The present paper is based on Marcelo Savio Carvalho's master dissertation (Carvalho, 2006), supervised by Henrique Cukierman. Both authors had been involved since 2004 in researching the beginnings of Internet in Brazil. We would like to thank the time and attention of Prof. Paulo Aguiar and Prof. Michael Stanton, who besides the interviews gave us access to their valuable personal archives, from where we took much of the information written here. In addition, we want to thank other contributions received from Alexandre Grojsgold, Carlos Afonso, Carlos Lucena, Charles Miranda, Demi Getschko, Ivan Moura Campos, Nelson Ribeiro and Saliel Figueira.

to the dictatorship by then ruling the country, followed by the dawn of a Brazilian information society and by its redemocratization.

A great part of the text is dedicated to present the several isolated attempts of forming academic networks in Brazil and the aspirations of the research community for connection with the outside world, touching issues involving the use of official standards for data communication protocols and negotiations with state-owned telecom companies, culminating with the consolidation of a national academic network in the early 90s.

Within this same time frame were also depicted some very important initiatives of the civil society, which began with amateur bulletin board systems, implemented by home users of personal computers, that later evolved into international connections to global networks of non-governmental organizations, which became a key element in the maturation process of the of implantation of the Internet in Brazil.

Finally, the text presents the paths along the 90s, which led to the emergence of the commercial Internet, arousing interests and intrigues for the commercial exploitation of this new market and its governance and control mechanisms.

The research was inspired by Science and Technology Studies—among many others, see Callon (1986), Latour (1987) and Law (1992), which show that the history of sciences and technologies can be historiographically richer when viewed not as a chronological sequence of "inventions" and "discoveries," but as a history that recognizes the contingencies, bifurcations and alternative paths which could have been followed, and especially the existence and the role of socio-technical networks.[2]

First moves for the construction of computer networks

At the height of the Cold War, stuffed in a period of nuclear bombs testing, conflicts in various regions of the planet and a starting space race, the United States of America's Department of Defense created the Advanced Research Projects Agency (ARPA), an agency which aimed, ultimately, to restore the USA leadership in science and technology, battered by the successes of Soviet Union in its nuclear and space programs. This Agency, in partnership with some handpicked universities, invested millions of dollars in various projects and, among these, the creation of a network that could connect different computers from the sponsored universities, distant and

2 The concept of "sociotechnical network" aims to overcome the separation between "science" and "society." The extension and composition of networks are always contingent, so that it is no longer possible to identify something purely "social" or purely "technical." Everything is in a constant entanglement, constituting a seamless fabric.

isolated from each other. This network, ARPANET, came into operation in late 1969 and has expanded over the following years (Abbate, 2000).

In parallel, some other non-commercial networks (such as USENET, BITNET, CSNET, FREENET etc.) have started to operate without any direct support from the USA government, working on a cooperative basis between academic institutions. Such networks represented an alternative communication between researchers from institutions that were not connected to ARPANET.

Amid the proliferation of these networks, two international organizations were working in parallel, since the mid-70s, for standardization in the scenario of telecommunications and computer networks: the *Comité consultatif international télégraphique et téléphonique* (CCITT), which acted as the spokesperson of the public postal services, telegraphy and telephony providers (at the time, were mostly state-owned enterprises), and the International Organization for Standardization (ISO), composed of national standards bodies. In 1983, these two organizations had combined their efforts and published a standardized reference layered model called Open Systems Interconnection Reference Model (OSI-RM) (Russel, 2013).

However, and while ISO and CCITT were specifying and refining their standards, a new set of computer network communication protocols—that had being developed since 1973 under the sponsorship of ARPA, and later called Transmission Control Protocol / Internet Protocol (TCP/IP)—was being tested and matured over the years, distinguishing facilities for interconnection between heterogeneous networks. Its adoption grew substantially after January 1st, 1983 when it substituted NCP (Network Control Protocol) and became ARPANET's official communication protocol, which allowed connecting to other networks that were already using or recently migrated to TCP/IP (Abbate, 2000).

After migrating to TCP/IP, ARPANET was split into two separate networks: MILNET (Military Network) to be devoted to the operational activities of the Department of Defense and ARPANET, which would be able to continue to pursue computer network research activities. Almost 2/3 of the existing hosts moved to MILNET and gateways between the two networks provided internetworking communication (Norberg & O'Neill (1996).

In 1986, the National Science Foundation (NSF), a governmental foundation to support research & development in the USA, created the NSFNET, a TCP/IP network maintained by the USA government, initially as a network backbone structure, connecting several universities and research institutions in some supercomputing centers, in order to share these expensive computing resources. In 1990 ARPANET ceased operations and its remaining hosts moved to NSFNET, which became the backbone of the, so called, Internet. This opened possibilities to connect with academic institutions from different countries, including Brazil, growing exponentially the number of machines and users connected worldwide.

Networks in Brazil and the state control

Data transmission started in Brazil as a matter of the State, specifically submitted to the interests of the Ministry of Communications (Minicom) that, by ordinances, reserved to Embratel, the state-owned Brazilian Telecommunications Company, the monopoly for installation and operation of data communication services in the country, leaving a few value-added services to the (also state-owned) local telecom companies, operators of the Brazilian Telecommunications System (Telebrás). At the end of 1988, these companies were also allowed to compete with Embratel in the provision of statewide data communication services (Stanton, 1993).

Leading government documents supported the deployment of networks in the country aiming at the competitiveness of the domestic industry and at the purposes of strategic military order. In their view, the domestic industry should achieve greater technological development in tune with other "developed" countries and, since Brazil was ruled by the military, geopolitical issues raised the telecommunications area into a strategic theme for national autonomy and security (Benakouche, 1997).

The state control over the flow and the disclosure of electronic information was not restricted to the Minicom. In the early 80s, the then powerful Special Secretariat of Informatics (SEI), created by the military government security agency, decided to intervene in this subject by creating the Special Committee on Teleinformatics, whose objective was to analyze the national landscape of telecommunications and informatics sectors and guide the government (including the Minicom) in directing a development policy, which should be integrated within the wider framework of the national communication and information technology policies (Benakouche, 1997). Later in its National Plan for Informatics and Automation, SEI had established guidelines relating to the so-called "Transborder Data Flows," in which it had the only and ultimate decision on authorizing computerized data communications across national borders (Lins, 2002). By that time, airline and banking networks were the only ones allowed to operate internationally, with their access points installed in facilities from Embratel, who was also responsible for the equipment operation (Stanton, 1993).

zurück

The first national data communication networks

The first data communication service in Brazil, offered in 1980 by Embratel to the market, was TRANSDATA, a point-to-point (not switched) network of private circuits, leased at fixed prices, calculated based on the distance between the ending points and the corresponding transmission capacity (Benakouche, 1997).

In 1982, Embratel created CIRANDA,[3] a pilot project for an information services network restricted to employees of the company and accessible from shared computers installed at their offices. The participating employees were also granted with the purchase of microcomputers with modems to be installed at their homes, in order to extend the reach of the pilot network (Benakouche, 1997).

In 1985, Embratel launched RENPAC, the national packet network, which was a public data transmission network that used the X.25 protocol (based on the OSI Reference Model). To increase its use, Embratel expanded the CIRANDA project to the general public, through RENPAC network, creating the CIRANDÃO[4] Project, an information service offering which few years later became the STM-400 service (Benakouche, 1997).

The difficulties of interconnecting Brazilian universities

In 1979, the National Laboratory for Computer Networks (LARC) was created by several universities in Brazil to integrate the institutional efforts in the area of computer networks, in order to generate a nationwide expertise in this area and to promote the exchange of scientific information and software through the integration of local computing laboratories (Rodrigues, 1987).

In 1984, LARC launched the Rede-Rio Project, aiming at creating a network to link the computers of some academic institutions in the state of Rio de Janeiro. The project proposed the study and implementation of OSI protocols, the training of professionals and the widespread use of RENPAC network within the academic community. This project received funding from the Financing Agency for Studies and Projects (FINEP), an organization of the Brazilian federal government devoted to the funding of science and technology projects in the country (Rodrigues, 1987).

Seeking alternatives to ensure the creation of an academic network in Brazil, the board members of LARC visited, in June 1985, the academic

3 Named after the Brazilian northeastern popular dance, where people get together in a big circle dancing and singing, drawing on the metaphor of cooperation.

4 “Cirandão” is the aumentative of “Ciranda” (see previous footnote). The announcement positioned “Cirandão” as an opportunity to redeem the democratic ideal.

zurück

network of *Deutsches Forschungsnetz* (DFN) in Berlin, Germany,[5] a supporter of the OSI protocols, as many European countries at that time. As a consequence of this visit, the Brazilian Science Information Network (BRAINS) Project was conceived to be a network that would interconnect academic institutions in Brazil. Since this network was planned to be similar to the DFN, it would be OSI compliant, which was accordant to what was recommended by the national information and communication policies running in Brazil. In April 1986, the technical director of DFN was in Brazil presenting the German project at the IV Brazilian Symposium on Computer Networks (SBRC) and visiting some national academic institutions (Rodrigues, 1988).

By 1987, there were more than 50 academic networks in over 30 countries worldwide. In Brazil, despite the operation of RENPAC network by Embratel, the academic community was still totally disintegrated, because Rede-Rio and BRAINS projects were, for several reasons, nothing else than pieces of paper, as well as some other projects for setting up regional or national networks in the country. At a meeting held at the VII Congress of the Brazilian Computer Society (SBC), in July 1987, Prof. Michael Stanton from the Pontifical Catholic University of Rio de Janeiro (PUC-Rio)[6] convened a birds of a feather session to discuss the importance of academic networks as well as to exchange information about experiences that began to take place at several institutions all over the country. That meeting led to another one, held in October 1987, at the Polytechnic School of the University of São Paulo (USP). At this one, called "Preparing for the National Research Network in Computer Science," happened the first attempt for recruiting allies,[7] as representatives from many academic and research institutions were invited and attended the meeting, together with the members of LARC, SEI, Embratel and the Brazilian National Council for Scientific and Technological Development (CNPq). As a result, it was planted the seed for a Brazilian academic network. In November of the same year, three Brazilian researchers—Alexandre Grojsgold (LNCC), Michael Stanton (PUC-Rio) and Paulo Aguiar (UFRJ)—attended the VI International Academic Networking Workshop[8] that took place at the University of Princeton, USA, in which they knew about several academic networks in the world (Rodrigues, 1988).

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5 There was a cooperation agreement between Brazil and Germany at that time that supported many technological projects, such as nuclear power plants.

6 In 1975, during the 1st Latin American Seminar on Data Communication at São Paulo, an access to ARPANET in the USA was demonstrated by the first time in Brazil. The international experts who carried out this task were Vinton Cerf (Stanford University) and Keith Uncapher (University of Southern California).

7 The formation of a socio-technical network depends on the ability of enlisting allies. The number of allies, their qualifications and how they interact in the network will result in success or failure of the network (Latour, 1987).

8 This series of workshops were attended by individuals who were pioneering the

Inspired by these meetings, in August 1988 LARC drafted a proposal to the recently established Ministry of Science and Technology of Brazil (MCT) for the creation of the, today called, National Education and Research Network (RNP). This proposal was based on the premise that data communication with other overseas research networks should be done through dedicated lines for a fixed cost, which needed the approval from Minicom and also from SEI (its authorization was needed for the international traffic of data). If the traffic routed through Embratel international access channels was priced according to volume of data transferred, the final cost would be more than ten times the estimated, turning the nascent academic network into an unfeasible project. In addition, according to the draft project, all the national connections to the upcoming RNP would flow via RENPAC network, and that institutions without mainframe computers could connect their PCs or minicomputers to a parent institution and, through a cooperative agreement, would have access to the RNP services (Rodrigues, 1988).

It was enough for the frictions to emerge. The telecommunications monopoly forbade the transport of third-party traffic within any customer circuits of Embratel (either local or abroad), thereby precluding the creation of gateways and, ultimately, the creation of a data communication network that could connect the academic community. The other contentious issue concerned the recovery model. Earlier, in January 1988, LARC sent to Embratel an application for the establishment of a dedicated connection to a foreign country for a fixed cost, in order to facilitate the creation of an international gateway for the upcoming RNP. Embratel negatively responded to this request, stating that this would violate the by then current standards against the sharing of network circuits as well as the billing process (which did not allow fixed costs). Embratel only waved with a possibility of solution, based in similar cases of other networks (such as for banking and airline companies) in which the costs, although variable per volume of data transferred, could have an estimated reduction of approximately 25% of the total amount to be charged if the international access from RENPAC network were used, which was refused by LARC (Rodrigues, 1988).

development of national networks in their countries. The goals were to educate, share experiences and encourage the connection to the Internet. These events were organized by Prof. Lawrence Landweber (University of Wisconsin), who also helped to establish many network gateways between the USA and other countries. The Brazilian attendees of this edition were sponsored by IBM Brazil.

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The first international connections

If, on the one hand, efforts to create RNP were facing political and economic issues, on the other hand the need for linking universities and research centers in Brazil with international networks was getting more and more urgent. By the beginning of 1988, the National Laboratory for Scientific Computing (LNCC) requested an international dedicated line (9600 bps) to connect to the University of Maryland in order to get access to the BITNET network. Embratel was initially reluctant to grant the request, fearing the problem of sharing circuits. This episode was only resolved—positively to LNCC—after a meeting in April 1988 at the federal capital, Brasilia, between SEI, Embratel, LARC and LNCC, when it was finally decided that this request was authorized by SEI and should be attended as quickly as possible by Embratel. More importantly, that meeting also decided that any other request made by any university for a non-shared connection to academic networks abroad would be automatically approved and should be promptly attended.

The successful access to BITNET in September 1988 was an enormous victory not only for LNCC[9] but also to the Brazilian academic community as a whole, although it had not been possible to implement the long-awaited international gateway in Brazil yet. This decision reinforced the interests of other institutions seeking their own international connections. So, following that path, the Foundation for Research Support of the State of São Paulo (FAPESP), led by Prof. Oscar Sala, initiated contacts with the Fermi National Laboratory in Chicago (USA), obtaining, as of November 1988, its international connection (4800 bps) to the BITNET and HEPnet[10] networks, which led to the creation of the Academic Network at São Paulo (ANSP). In sequence, an awaited connection from UFRJ to the BITNET via the University of California at Los Angeles (UCLA) finally took place in May 1989.

Thus, Brazil ended the 80s with a connection to HEPNET and three distinct islands of access to BITNET, whose communication with each other occurred only through international network routes. The end of the restriction on third-party traffic in the upcoming years opened the doors to resolving this situation as well as for the creation of a national

9 LNCC was looking for its connection to BITNET since May 1985, after contacts with Glenn Ricart (University of Maryland), who had been in Rio de Janeiro promoting BITNET. And even before BITNET went live in Brazil, LNCC had an account on the system of the University of Michigan, which was accessed by international dial-up, and through which they could send and receive messages.

10 High-Energy Energy Physics Network (HEPnet) was an international network that linked academic and research institutions dedicated to high energy physics. This network used the DECNET communication protocol.

zurück

network that would allow the sharing of access to international networks (Stanton, 1993).

Since the early use of BITNET, it was clear that only email services would not be sufficient for most academic users, whose requirements went through the interactive remote access to applications and more comprehensive file transfer, features that were already available on the existing Internet, which by that time was still inaccessible from Brazil and practically unknown from the great majority of Brazilian population, except for a few researchers who had international experience and started demanding for it.[11]

The resumption of the Brazil national network and the dawn of the Internet access

The creation of an infrastructure for Internet access collided with the disputed choice of communication protocols. SEI was a strong advocate of the OSI model, and although BITNET was initially tolerated as a pragmatic and immediate solution to a restricted service, the technology of the Internet (TCP/IP) was not considered a suitable alternative solution, since it was not governed by formal international standards bodies.

With the beginning of the Fernando Collor presidential government in 1990, it took place the dismantling of the national communication and information technology policy, through reducing the power of the SEI, then transformed into an information technology policy department of the Science and Technology Secretariat of the Presidency. An immediate consequence was the weakening of frontal opposition from the government to the academic use of the Internet technologies, although it was still maintained (and subsequently enhanced)[12] the government's preference for OSI technologies.

The implementation of a national academic network, as widely known, required a heavy and expensive infrastructure, therefore relying strongly on governmental support. In September 1989, in a keynote speech at SUCESU, the most important IT Conference and Exposition event at that time, the

11 In September 28th, 1987 UFRJ received a letter signed by Prof. Lawrence Landweber, on behalf of Stephen Wolff (NSF Division Director for Networking and Communications Research and Infrastructure), which granted access to the Internet. Unfortunately this was not enough, since besides the inexistence of a data communication circuits between the two countries, there was no equipment capable of routing IP traffic available in the Brazil at that time, and importing one was very expensive and too much complicated due to the existing Information Technology market reserve policy.

12 A presidential decree published on May 8, 1992, stated about the mandatory adoption of OSI by the entire federal public administration, which should also follow the newly published Brazilian Government OSI Profile (POSIG).

secretary of science & technology of the federal government officially recognized the need to improve the national infrastructure of communications as well as to involve (and commit) the various R&D actors in cooperative activities in order to contribute more effectively to the development of the RNP. A working group was created, under the coordination of Tadao Takahashi (from CNPq), who set up and executed a strategy to implement a network architecture similar to the one adopted by NSFNET in the USA, i. e. with three levels: the national backbone, regional networks and institutional networks. In Brazil, the national backbone would be a project of the federal government, while regional networks would be the responsibility of the state governments (individually or collectively). In functional terms, the regional network would interconnect institutional networks in a given region, and the national backbone of the RNP would provide interconnection services between regional networks, as well as international connections.

The communication protocol of the new national network walked toward TCP/IP, but to accommodate some interests and (unlikely but possible) future requirements for OSI, the national backbone and the regional networks should adopt multiprotocol routers. RNP began its implementation, starting with the state backbones.

Despite the pressure from the government (and some sectors of the IT market), it was already clear to most universities in the late 80s, that TCP/IP would supplant OSI at the global level, at least in academic and research networks. This academic view resulted in the first official[13] use of technology to support TCP/IP in Brazil when, in September 1990, the project for a network of the state of Rio de Janeiro was announced, stating that it would be connected to the Internet. This project, funded by the Foundation for Research Support of the State of Rio de Janeiro (FAPERJ), initially interconnected three institutions—LNCC, UFRJ and PUC-Rio—and was called Rede-Rio.[14] Although its deployment has taken almost two years to conclude, it served as a model for other states and for the recasting of the national network project that was beginning to take shape.

In November 1990, RNP team organized a workshop to which Barry Leiner was invited to present the organizational structures of academic networks in the USA and also internationally. Leiner was a managing director at ARPA and a founding member of the Internet Activities Board

13 Paradoxically, at that moment, the position of the government was already being smoothly subverted in many research laboratories at several federal institutions, since their newly acquired scientific workstations already came with Ethernet LAN adapters and TCP/IP protocols support, which were immediately put into work (Stanton, 1998).

14 Following the suggestion of Prof. Michael Stanton, although being a different and new network project, it took the same name of the old LARC project (Rede-Rio), as a way to honor the initial efforts and work done in the development of computer networks in the State of Rio de Janeiro.

(IAB), the organization that oversaw the operation of the Internet, and was also responsible for its international *liaison*. Leiner was also part of the Coordinating Committee for Intercontinental Research Networks (CCIRN), an organization that wished to rationally arrange continental networks interconnections. Before coming to the workshop, Leiner was advised by Steve Goldstein (NSF) on the existing conditions in Brazil, as presented to him by Michael Stanton. Goldstein also shared with Leiner his worries on avoiding proliferation of monoprotocol communication links between isolated institutions or subnational networks in Brazil and the NSFNET in the United States. Instead, the preferred solution would be to establish a connection between the backbones of the two continents, but since there was no such a thing as a "South American backbone," the (temporary) solution for Brazil would be connecting at the highest level in the country, i.e., at some point of the national backbone, which was still on paper.

The same workshop that brought Barry Leiner was also attended by Chris Jones, from the *Conseil européen pour la recherche nucléaire* (CERN), the European Laboratory for Particle Physics, located in Geneva, Switzerland, which happened to be the best place in terms of European connectivity at that time.[15] That stimulated the Brazilians to have two international links (North America and Europe) but despite the ideas of multi continental connectivity for the nascent national academic network, the international connection of Brazil took only across the United States[16] for many years.

The first internet connection in Brazil finally came into place in February 1991 when, after increasing the capacity of its connection to the Fermilab to a 9600 bps link, FAPESP began transporting the TCP/IP traffic of ANSP (besides BITNET and HEPnet traffics) through its access to the Energy Sciences Network (ESNET) which was connected to NSFNET, which, in turn, was part of the Internet. The organization of Internet access in Brazil by the end of 1991 was highly cooperative, where each participating institution funded its connection to São Paulo (and later to Rio). To avoid a repetition of what already happened to the BITNET connections in the country, the ultimate solution referred again to the implementation of a national backbone, definitely turned into an obligatory passage point (Callon, 1986) in the implementation of academic networks in Brazil.

15 CERN was a sticking point in the operation of networks in Europe, besides having the best communication link between Europe and North America (EASINET-NSFNET), and besides being the end of the transatlantic link of HEPnet

16 If the connection with Europe had happened as first imagined, maybe Brazilians could have participated at the beginning of the World Wide Web project, as CERN was its place of origin in early 90s.

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The thrust of the third sector

Electronic access to information was not a privilege of academic institutions, as since mid-80s many Bulletin Board Systems (BBS) existed in Brazil, where their users exchanged messages among themselves and even internationally through FIDONET. Among users of BBS was the Brazilian Institute of Social and Economic Analysis (IBASE), a non-governmental organization founded in 1981, which in 1988 created Alternex, a BBS that served to civil society organizations (research, human rights, ecology etc.). In mid-1989, Alternex had linked up, via UNIX-to-UNIX Copy (UUCP), to the Institute for Global Communication (IGC) in California (USA), which later became the access point to the Internet for the Association for Progressive Communications (APC), an international organization which IBASE was part of. To facilitate international access for Alternex, IBASE obtained support from the United Nations Development Program (UNDP), which enabled it to receive foreign microcomputers and workstations, which were forbidden to be imported by the information technology market reserve[17] institutionalized by the national communications and information technology policy (Afonso, 1996).

At one of its preparatory conferences held in Nigeria in 1990, the United Nations delegated to APC the coordination and deployment of the communications infrastructure for its future global conferences. This delegation promoted an enormous step to Internet access in Rio de Janeiro, as IBASE, the APC representative in Brazil, was made the responsible for coordinating, planning, implementing and operating the network of information dissemination during United Nations Conference for Environment and Development (UNCED or Rio '92), the main global conference on environment and development that would take place in June 1992, in Rio de Janeiro, Brazil. In order to reach its scientific and political goals, Rio '92 needed to exchange information with the outside world and the Internet was clearly the best way to accomplish it (Afonso, 1996).

The international importance of the conference facilitated the recruitment of allies, resulting in a broad government support at all levels, plus the support of the UFRJ, which allowed a quick installation of (international and local) connections with a very high capacity for that time (64 kbps). This infrastructure set up for the Rio '92 event expedited deployment of Rede-Rio project, which had included, in addition to an international link, a network operations center, originally installed at UFRJ. This effort boosted the São Paulo network (ANSP) to increase its access to 64 kbps

17 In order to obtain a better understanding of the so-called computer market reserve policy that occurred in Brazil during the 70s and 80s, (Marques, 2003).

and leveraged the implementation of the first national backbone of RNP, providing Internet access to the other states of the country by sharing the ANSP and Rede-Rio networks.

The Brazilian Internet Company and commercial access

In some countries, mainly in the United States, the non-academic usage of the Internet started to become a reality, especially with the emergence of commercial Internet Service Providers in the early 90s. This trend would soon be followed in Brazil.

After the Rio ’92 event, IBASE, as a member of Rede-Rio, expanded its Alternex services in order to operate as an Internet access provider to the general public, the first in Brazil. By that time, the Internet began to be more widely known by the Brazilian society through articles in newspapers and magazines. The provisioning of access services aroused interests (and intrigues) in the running of the newly created Brazilian market for Internet access. Controversial issues emerged from the “commercial” traffic Alternex was carrying through a supposed strictly academic network and, although IBASE and Rede-Rio had been allies until then, a split happened and Alternex networking services ended up being rerouted to the Academic Network at São Paulo in order to not be disconnected from the Internet, as ANSP did not had such an issue (Afonso, 1996).

In late 1994, the federal government announced, through the ministries of Science & Technology and Communications, its intention to promote the development of the Internet in the country, charging to the state-owned Embratel the creation of the infrastructure necessary for its commercial exploitation. But without any experience in dealing with TCP/IP, Embratel had to look for help with RNP people in order to assembly the infrastructure of a high capacity network capable to support the implementation of the commercial Internet, based on experience RNP gained in the deployment of the academic Internet (Guizzo, 2002).

Finally, Embratel began operating its service for Internet access via dial-up modem (14,400 bps) on a trial basis through a public test with five thousand users. In May 1995, it began to offer the service in a definitive way. Nevertheless, the monopoly of Embratel displeased the private sector and some other sectors of society. Much had been written in the press about the fear of the emergence of an “Internetbrás”[18] which, according to the malcontents, would plunge the country into a new market

18 The suffix “brás” denotes that the economic activity in reference is exploited by a state controlled entity, as for example in “Petrobrás,” the state controlled company for the exploitation of petroleum, or Eletrobrás, the equivalent to electric energy business.

reserve. Accordingly, the Federal Government, represented by the Minister of Communications (Sérgio Motta), announced in the same year that the Internet was a value-added service where there would be no monopoly, and that telecommunications companies (still state-owned) could not provide access to end users anymore (Prata, 1999). Then an inter-ministerial decree from 1995, issued by MCT and Minicom, created the Brazilian Internet Steering Committee (CGI.br), with the purpose of coordinating and integrating all Internet service initiatives in the country, comprising representatives of the government, backbone operators, service providers, academia and the end user's community.

Since that decision, alongside with the explosion of the World Wide Web, many Internet access and content service providers appeared (and disappeared) in the Brazilian market. The Internet started to appear on TV shows and soap operas, new professions emerged (web designer, webmaster etc.), new concerns arose (such as privacy, security etc.) and cyberspace opened for a few million Brazilians, today classified as "digitally included citizens."

Conclusion

The analysis of the early days of the Internet in Brazil may show that, as proposed by Edwards (1996), technological changes correspond to technical choices, in turn inextricably linked to political choices and values socially constituted, where technology supports (and is supported by) discourses that emerge among the complex interactions between engineers and scientists, funding agencies, government policies, market laws, civil society institutions, ideologies and cultural frameworks.

These complex interactions show the interplay between nationalism and technology and between technology and the government, first the dictatorship and then the civil power, out of the conventional frame of the so called "sociology of interests." The interests are complex and multiple, especially because they are not fixed but rather are displaced along the negotiations between the various actors (humans and non-humans) involved in the implantation of the Internet in Brazil. No actor had the control of the outcome of their negotiations, but rather were leaded to the risky and unforeseeable task of building and stabilizing a technological artifact.

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Robert Fano, an Italian Computer Scientist from Project Mac to the Internet

Benedetta Campanile

Abstract
In 1938 Italian-American Robert Mario Fano emigrated to the United States following the issuing of the racial laws in Italy. Extrovert and determined, in the United States Robert found an adoptive homeland in which his young talent could be nurtured, a place in which science was fostered by democracy and freedom of choice. In the US he became a pioneer of the concept of "making the power of computers directly accessible to people." He believed that the tools of information processing could build a better society in which everyone would have the same opportunities to make their dreams come true. In fact, in the early 1960s, he led the launch of the Massachusetts Institute of Technology's Project MAC which "took the first step in the computer revolution that changed the world," as Professor Fano himself said, and brought the Internet into being.

> "Perhaps the best opportunity for personal use of computers will come about through "time-sharing," the technique which divides the use of a large central computer among several users ... Within a few years I would expect a number of time-sharing computer systems to be interconnected—capable of communicating with one another as well as with many remote subscribers." (Fano, 1968a, p. 6)

With this prophetic sentence in 1968, Italian-American Robert Mario Fano announced the dissemination of computer systems as tools for communication and connection. He pioneered the concept of "making the power of computers directly accessible to people." In fact he believed that the tools of information processing could build a better society in which everyone would have the same opportunities to make their dreams come true. In the early 1960s, he launched Massachusetts Institute of Technology (MIT)'s MAC project, which "took the first step in the computer revolution that changed the world," as Professor Fano himself said, and brought the Internet into being (Fano, 2014).

Born in Turin in 1917, Fano was a twenty-one-year-old student of the School of Engineering at the Polytechnic of Turin when the Fascist government's racial laws hit his Jewish family. His father, Gino, from a wealthy Jewish family originally from Mantua, abandoned his career teaching mathematics at the University of Turin and fled to Switzerland, whereas his older brother, Ugo, a physicist from Enrico Fermi's Via Panisperna group, emigrated to the USA. Robert brought his studies in Italy to an end and joined his brother overseas. Here he was admitted to MIT in Boston, where he graduated with a BSc in Electrical Engineering in 1941 and an Sc. D. in Electrical Engineering in 1947. Before becoming Project MAC's director, Robert had a long career in MIT where he started as teaching assistant in the electrical engineering department, from 1941 to 1943, and then moved onto being instructor in 1943-44. Then he joined the Institute as a Radiation Laboratory staff member. In 1951 he was appointed Associate Professor of the Electrical Engineering Department at Lincoln Lab and in 1962 became Ford professor (Campanile, 2018; Wildes, 1986).

In the spring of 1963 Fano was granted the support of the Department of Defence's Command & Control Branch of the Advanced Research Projects Agency (ARPA), part of the Naval Research Contract Number Nonr-4102(01) office, for a program focusing on enquiring into the relationship between human users and computers. With people potentially able to work from remote locations, namely online, this system aimed to examine the ways in which direct links to on-line computers could aid people in their individual work. Fano grasped that the search for solutions to increase man-computer interaction would broaden computers' integration into human life for solutions to research, design and employment issues and in the knowledge-based services (management, education, banking, etc.) (Fano, 1972, pp. 1249-1250). The program was the brain child of experimental psychologist Joseph C. R. Licklider (1915-1990), the author of *Man-Computer Symbiosis* (1960) (Licklider, 1960, pp. 4-11), and director of ARPA's Information Processing Techniques Office (Fano, 1998). Licklider's was an ambitious goal, a "Galactic network," a universal network of computers connected to one another for online work (Licklider & Taylor, 1968) and he broached this issue in a memo to the "Members and Affiliates of the Intergalactic Computer Network" in April 1963 (Licklider, 1963).

Fano wrote the plan after discussing the potential feasibility of such ideas with his colleague Licklider on a return train trip from a conference in Virginia in November 1962. He brought Licklider's project to the MIT together with $2 million a year for five years and a new challenge for himself, because he was not MIT's greatest computer expert (Flamm, 1987). The MIT received a funding total of $25 million from 1963 to 1971 (Reed, Van

Atta, & Deitchman, 1990, p. 19 [14]). The contribution of academic research laboratories was fundamental to the history of computer science, but it has been overshadowed by the emphasis accorded by historians to the role of computer companies and military objectives (Garfinkel, 1999, p. viii).

Initially MIT named this strange project simply "FF"—short for "Fano's Folly"—because it seemed to be one of his crazy ideas. Fano's aim was to set up a new research lab, but administrative obstacles prevented people from other MIT labs joining it without resigning from their existing positions. Therefore, the lab had only one physical employee while the others worked online, a new virtual way of working which revolutionized the idea of the physical laboratory. The need to identify the research laboratory and its only employee obliged Fano to find a name for it (Campanile, 2018, p. 312). During a dinner party on the night of April 1, 1963, with Marvin Minsky and John McCarthy, Robert Fano coined the name MAC, an acronym with two meanings: Machine Aided Cognition, as the goal of the project, and Multiple-Access Computer as the tool, because it was based on a new technology, time-sharing (Garfinkel, 1999, pp. 6-7).

Project MAC's starting aim was to create the "illusion" for multiple users of having a private computer to themselves (Fano & Corbató, 1966, p. 128). In actual fact, time-sharing was based on rapid time division multiplexing of a central processor between several users. So each user operated a teletypewriter or other terminals online.

This new way of working with computers had been on trial at the MIT Computation Center since 1961, when John McCarthy had explained that a multiple-access computer system could improve user capabilities because it could connect up a large number of people simultaneously. He named this system "time sharing" (McCarthy, 1983, p. 2). In effect the term "time-sharing" had been in use in programming in SAGE (Semi-Automatic Ground Environment) Air Defense System for some time. McCarthy introduced the concept of time-sharing as a community utility to encourage a new type of processing to save time in preparing programs and waiting for computer results.

A copy of a Computation Center system, named "The Compatible Time Sharing System" (CTSS), was made for Project MAC to explore the potential of the online man-computer partnership (Corbató, Dagget, & Daley, 1962; Lee et al., 1992). The CTSS was the brainchild of the associate director of the Computation Center, theoretical physicist Fernando J. Corbató (1926–2019), "Corby," who implemented a multiple-access computer capable of both batch and time-share processing.

Indeed, time-sharing was an alternative to conventional batch processing which "had made programming a hard task" (Garfinkel, 1999, p. 3), because computer users spent long periods waiting for task queues to be processed. On the other hand, the project's goal was to show that continuous dialogue between users and machines was possible in which computers would act as man's intellectual assistant and the man-computer partnership would be non-hierarchical (Fano, 1965, p. 56). Project MAC was described by Fano in 1964 in his ARPA *Report*: "Project MAC was organized as an interdepartmental, interlaboratory 'project' to encourage widespread participation from the MIT community." There were thirteen participants from all sections of the Institute. "Such widespread participation is essential to the broad, long-term project goals for three reasons: exploring the usefulness of on-line use of computers in a variety of fields, providing a realistic community of users for evaluating the operation of the MAC computer system, and encouraging the development of new programming and other computer techniques in an effort to meet specific needs" (Fano, 1964, pp. I; X).

The "MAC Man"

Fano transformed himself into "Mac Man." Indeed, if Corbato was called "Mister Time-Sharing," it was Fano who shared his new belief in "time-sharing" with colleagues inside and outside MIT and within the Federal Government. In fact, at the start of the project, Fano organized a summer study school at MIT which was attended by 100 participants from the US and Europe. The meeting raised scientific awareness of the project's aims. With his empathy, likeableness, enthusiasm and determination, Fano built up a network of people—his academic colleagues—who were to test the new computer system. The same people would set up the network on which internet technology was to be based.

In May 1983, at MIT's Electrical Engineering Department Celebrations, Fano argued that time-sharing had been a revolution, because in the late 1950s it was mainframes which had been the computer market trend. These computers were big, expensive machines and users could not even conceive of owning one. The key companies, such as IBM, were mainly interested in large-scale commercial batch processing applications. This is why Robert Sproull, at that time director of ARPA, became convinced that the Federal Government should intervene to develop the new time-sharing technology (Reed, Van Atta, & Deitchman, 1990, p. 19).

In 1963 the CTSS had 30 on-line users and, surprisingly, some of the same core principles described for the first version are still relevant in today's cloud computing systems (Hu, 2015, pp. 53-54). Very soon, 200 users in 10 different academic departments were connecting to MAC computers via the MIT telephone system. Fano observed that people were communicating with one another through computer commands as if MAC was a communication system. For Fano and his assistants this was an important social phenomenon because it was computer users working together which shaped the first net community (Fano, 2014). After three years of experience, "the system and its users have developed like a growing organism" (Fano & Corbató, 1966, p. 136). Through the system's features, and "message central" storage and "permit" commands in particular, users could communicate that they had stored private files in a public memory location and authorize others to use these files. Therefore, once people had been authorized to use files owned by somebody else, they could "link" to these files and use them as if they were their own (Fano, 1967, p. 31). Thus time-sharing allowed users to move files, data and programs (Lee et al., 1992, pp. 14-35). This "ease of exchange had encouraged investigators to design their programs with an eye to possible use by other people" (Fano & Corbató, 1966, p. 138). Moreover, a memory protection mechanism with password access prevented theft or accidental deletion of information.

The availability of a physical area on which to collect data and programs was one of the system's most significant features as it concretely configured electronic media as a support for immaterial goods, "information," just as the paper in the place of papyrus had done for commercial calculations in Europe at the end of the seventeenth century, marking the abandonment of the abacus in favor of so-called Arabic numbers. In fact, the availability of a "core memory" acting as buffer allowed all devices—mass memories, core memories, central processors and input-output channels—to communicate with one another. The search for an efficient means to replace paper as a support for the recording and transfer of knowledge had begun with MIT scientist Vannevar Bush (1890-1974) in 1945 (Bush, 1945, p. 102). The latter hypothesized that his Memex could work with magnetic tapes, but the period's still rudimentary mechanical technology had blocked his initiative (Campanile, 2016, p. 212). Twenty years later, new magnetic media, magnetic drums and new digital computers guaranteed optimal performance, even if the costs were still too high as compared to paper:

> A page of single-spaced text stored in the disk file of the current MAC computer system costs approximately 10 cents per month. We see no reason why recording in the mass memory of a computer system should not become competitive with other recording media (David, Jr. & Fano, 1965, p. 245).

The innovation was time-sharing's ability to virtually duplicate memory and processors for individual users. This was based on the concept of a functional subdivision of hardware into shared equipment serving the same function.

zurück

The duplication of each element was designed to respond to average user demands as a group rather than as "typical users." This hardware management mechanism oriented scientific research toward memory-centered as opposed to processor-centered systems (Fano, 1965, p. 64).

The path chosen was the right one and Fano pushed Project MAC's research in the direction of the best possible knowledge representation through the use of high level program language to improve computer utility and user dialogue. The system's services were organized into commands, also called instructions, that system users could make to the system to implement programs. Users could use the system's various languages for several applications: FAP, MAD, COMIT, LISP, SNOBOL, a limited version of ALGOL, and two problem-oriented languages named COGO and STRESS, for engineering applications (Fano, 1965, p. 59). This was to lead to the reuse of programs or parts of programs by the largest number of users. For example, to edit text, users could use the Michigan Algorithmic Decoder language (MAD) to make simple alterations, corrections or otherwise change the program's text (Fano, Corbató, 1966, p. 132).

High level language was thus an interface between natural user language and the computer's machine language. This simplification of access to information stored on mass devices would extend the use of computers to a larger number of unskilled users, a choice which would generate real change in knowledge sharing and transmission and in the establishment of large economic organizations (Damascelli, 1998, p. 108). Hence, it would make information exchanged on the web the "digital gold" of the twenty-first century (Floridi, 1997, pp. 49-52).

The network as a new social model

Networks and knowledge sharing were the MIT scientific community's new social model. As historian Patrice Flichy has written, it was through time-sharing that MIT's scientists modeled the new computer environment "in terms of their own practices and representations of modes of sociability" (Flichy, 2008, p. 28). Interaction and joint working was standard behavior between MIT's scientists, as Fano well knew. In fact, Robert had accepted the challenge to work on computers for DARPA precisely because he was counting on the help of his friends and colleagues at MIT's Computation Center. With Project MAC this cooperation was widened to distant colleagues (Campanile, 2014) and Licklider called this social organization a community "of *common interest*" (Licklider & Taylor, 1968, p. 38). In fact, unlike other universities MIT was made up of *a community of equals* in which each member's status was based essentially on merit

zurück

(Flichy, 2008, p. 29). Joint working was more intense when the aim was to network computers deliberately designed to differ, as time-sharing did. Differences—gender, nationality, competence, religion—were a value at MIT. The joint working principle allowed complex software to be created as an aggregation of programs drawn up by different people. MIT served as a model for other institutions (Kaiser, 2012, p. 5) and thus a new computer service dimension had taken shape: communication between users mediated by computers.

Time-sharing was a change in direction in computer production. IBM agreed to modify MIT's computer, IBM 7090, for time-sharing use and Bolt Beranek & Newman and DEC created time-sharing systems. DEC made the first minicomputer, PDP-1, for use in time-sharing.

The quality of knowledge-based services

In 1968, in his paper *On Increasing the Availability and Quality of Knowledge-Based Services*, Fano clarified that decision-making quality was directly proportional to the amount of information available. This is why the time-sharing system, which again allowed several sources of information to be brought together, consequently improved the quality of knowledge-based services.

In fact, the time-sharing system was to increase the quality of the information industry in the same way that the industrial process had improved handicraft work. Increasing the number of computers connected in time-sharing meant more users could share specialized knowledge. The network could create a shared mass of knowledge and science and society's more challenging problems could be solved. For example, this system could generate significant improvements in the management of the large volumes of information needed in knowledge-based services such as education, health and banking (Fano, 1974, pp. 6-8).

Fano was thus concerned with two issues: knowledge production and fruition. He suggested a solution: good symbolic representation of knowledge recorded in a computer's memory for knowledge reuse. This involved building good software interfaces with which to access information, which were to compensate for the physical limits of the technology. For this reason he pushed the development of research funded by Project MAC in the direction of the creation of advanced interfaces capable of interacting with the users via innovative tools. An example was a multiple-display system developed by the MIT Electronic System Laboratory for computer-aided design which included two oscilloscope displays with a character generator and a light pen (Fano, 1965, p. 57).

zurück

Thus Fano highlighted the following issue: is mass production of knowledge-based services possible? His answer was that increasing quality was a feature of mass production and four conditions were required:

1 dividing tasks up into specialized activities connected by strict logic;
2 creating a flexible network infrastructure for transporting and distributing information;
3 creating an interface including all subjects which produce, require, distribute, and consume information;
4 finding investment capital to create an information industry (Fano, 1967, p. 36).

In this problem solution strategy Fano demonstrated a more concrete vision than Vannevar Bush, whose prophecies on information technology's future were more utopian.

Computer Utility Service

Fano foresaw that computers would have a profound impact on social functioning—in laws, regulations and business operating procedures—and would also potentially create a new form of society. In placing computer at the service of individuals, by means of information processing, such services would provide "thinking tools" to individuals to aid them in their everyday intellectual labor. Fano believed computers increased human skills and empowered minds by providing a high volume of information on which to base accurate decisions. Information overload was a real danger and people to acquire, record, search and use this information were needed. A similar need inspired Bush's Memex, but the technology was not yet ready for a suitable solution to be found at the time. Now Fano and his group could handle data with digital computer for better effectiveness in searching and using information.

Fano and Corbatò popularized the public utility metaphor for time shared computer services, introducing the notion of "customer" which changed computation's meaning. This meant that computer utility or information utility were general and measurable services. Supplying computer power to individual "customers" would mean that users could access services "where, when and in the amount needed" (Fano, 1967, p. 36). This was the new computer utility model that McCarthy had proclaimed in 1961, Martin Greenberger had theorized in *The Computers of Tomorrow* (1965) and Fano promoted as the computer of the future (Greenberger, 1962, p. 8). Furthermore, new technologies could measure and accurately price the amount of information transferred and exchanged. This measurement then completed the process by which intangible 'information' resources were commodified and made it comparable to other products, but with a substantial difference linked to the "clear separation between sale and transfer of the product" (Floridi, 1997, p. 50). In fact this different property exchange mode modified agricultural and industrial society's product purchase concept according to which producers handed over their goods in the act of transfer to the buyer. As Fano and Corbatò explained, the new information utility was a loss-free service supplied to an "entire community" of knowledge resembling a "powerful library." Fano "was among the first to tell businessmen that 'time-sharing' is part of a growing trend to market the computer's abilities much as a utility sells light or gas" (Hu, 2015, pp. 53-54). Associate professor at MIT's School of Industrial Management, Martin Greenberger, also compared the change from batch to time-sharing to the gradual electrification of cities (Greenberger, 1964; 1965) and to the distribution of telephone services (Parkhill, 1966, p. 52).

Actually, the partitioning of computer services offered by time-sharing more closely resembled TV program broadcasting. In fact, the customers would be served round the clock and a single broadcasting station, the CTSS, allocates programs and resources to a plurality of users. However, unlike broadcasting, time-sharing computation was a product with dynamic features that needed to be actioned by users as it took place via two-way dialogue with input and information as feedback, such as in the system login service which needed direct interaction between system and user.

Demands for a round-the-clock service became evident when Fano's scientist colleague Joseph Weizenbaum (1923-2008), the author of the *Eliza* program, waited in Fano's office to complain that the system did not work at night (Garfinkel, 1999, p. 9). This was a personal satisfaction and goal for Fano's team. The conditions for the birth of an information age were thus created: service supply and public utility demand.

"Freedom of choice"

Fano described computers as a mental aid, a much needed tool with which to manage society's new complexity (Lee, David, Jr., & Fano, 1992, p. 36; David, Jr. & Fano, 1965, p. 244). Fano (1968, pp. 259-260) wrote:

> It is also important to note that a human society equipped with much more effective means of gathering and using data will allow much more individual freedom and more inequality among its members, without running the risk of becoming chaotic and losing control of itself.[1]

1 Translations are the author's own.

In fact, a mass of information needed to be acquired, recorded, sought out and used if many problems were to be solved, such as those of an educational, technical, managerial, economic, political, social, legal, ethical and philosophical nature.

Fano believed it necessary to adapt computers to people's desires and needs, rather than vice versa. Good interface design could impact on user efficiency as it limits its usability. Thus, designing a computer system can limit and shape the way a community of people interacts. Consequently, it was software designers' responsibility to develop easy-to-learn interaction methods. He also stressed that a community's characteristics influence a computer system's evolution in feedback.

Fano believed that the use of computers in any tasks involving people could enhance "freedom of choice:"

> In today's society we force a certain amount of conformity simply because if there weren't such conformity we wouldn't be able to manage the situation ... Now all this can be changed substantially by better means of information processing. In other words, in an information-rich society, the individual will have much more freedom of choice because society will be able to stand much more diversity among its members without the results being chaotic (Fano, 1968a, p. 5).

Fano wrote that information was the new society's cement and computers were a tool with which to satisfy knowledge transfer, management and production needs: "The state of equilibrium that society will assume with respect to the new boundary conditions will depend largely on how each individual, in his roles as worker and citizen, will decide to exploit the new tools available" (Fano, 1967, p. 262). With the new digital technologies even the marginalized social categories, such as black minorities, could exercise their "freedom of choice," which was the possibility to shape their own future and the recognition of their existence through new job opportunities. In fact, the optimistic view of the report of the Joint Committee on the Economic Report to the US Congress denied the pessimistic one proposed by Norbert Wiener, who reflected on negative incidence of automation on employment (*Cybernetics; The human use of human beings*). The Committee, instead, highlighted the benefits of technology, automation, and economic progress in the Automation and Technological Change Report (Douglas, 1955, p. 11). The aforesaid report spoke of new jobs promoted by new government policies regarding the use of automation technologies. However, the creation of different jobs compared to the past was seen as an element of uncertainty and fear with respect to tradition (Caffè, 1967, pp. 431-444).

Fano firmly believed in the new digital paradigm of computation based on the "jump" function. This new paradigm exceeded the old model of the continuous circuit where it was not possible to identify the discontinuity between the values of the magnitude examined. This digital paradigm was also fitting the need to describe the wealth of the new society in which each individual, although belonging to minority social groups of race, gender and religion, could be represented in its singularity and, therefore, in its "freedom of choice."

The digital paradigm was a metaphor in the struggle for civil rights, in the name of Martin Luther King, his prominent supporter, and J. F. Kennedy, his most sensitive interlocutor, which was making its mark on the US. In his manifesto *A Nation of Immigrants* the latter had introduced the concept that it was diversity that had made America great. The nation's strength was therefore its "composite" character and its ability to give a voice to every difference. Digital computers were the technology best suited to rapidly evolving societies that had to handle large amounts of information to master the complexity of their times (Kennedy, 2009, p. 1). The idea of adapting technology to human beings was a consequence of the cybernetic concept introduced by Fano's friend, colleague and neighbor at MIT, Norbert Wiener (1894-1964) (Pogliano, 2007, p. 91).

The time-sharing computer system was creating a community in which diversity was a value because computer helped to manage differences without causing confusion. "Information" was becoming the mirror of the community that the computer system served since it was the archive of that community's knowledge (Fano, 1974, p. 4).

Eugene Fubini (1913-1997), who emigrated to the U. S., like Fano, in response to Nazi persecution (Fubini, Brown, 2015, pp. 61-64), was a supporter of Project MAC when he was undersecretary to the American Ministry of Defense, also expressed the need to manage social complexity with technologies that had: "the ability to extend a process that is uniquely human: the mental process that uses information" (Fubini, 1968, p. 397)

In Italy distrust of new technologies was fueled by some politicians' fear of American technological invasion. In this regard, Fubini argued that:

> It seems to me that the opinion of those who argue that for Europe the best way forward is to minimize the interdependence of the two continents is illogical. European technological capabilities will develop much faster if the "old continent" continues to use the flow of information and knowledge coming from America, instead of concentrating its efforts on national or local self-sufficiency criteria. By this I do not mean to defend myself in the Americanization of Europe, but rather in the Europeanization of certain technological procedures

zurück

> and certain commercial methods which have proved to be very profitable in America (Fubini, 1968, p. 396).

Fano believed that the employment of computers in any task involving people had many social consequences and, in some instances, that these consequences could be adverse. For example, job destruction (David, Jr., & Fano, 1965, p. 246), the subtraction of data and code and individual control.

Related to this issue, in the US a commission was set up to assess the impact of automation on employment levels that made statistical projections over the next ten years: *Automation and Economic Progress* (US Congress, 1964, p. 7). The report was reassuring, but it was not discussed because military commitments abroad called politicians' attention to other priorities (Caffè, 1967, p. 438).

Privacy was considered a fundamental American freedom and an unquestioned constitutional right. The menace of bureaucratic control of individuality and citizens' privacy was a real Federal Government concern because there were plans to set up a National Data Center or Data Bank "to reduce the costs of duplication of files and to provide more rapidly available information to those with legitimate need" (Paul Baran, computer expert with the RAND corporation, US Congress, 1966, p. 121). The Hon. Frank Horton said: "The Subcommittee believes it is important that we consider this question before the establishment of a National Data Center or bank becomes a fact" (US Congress, 1966, pp. 1-4). A data bank was the trend for "increasing demand for a centralized facility [...] into which would be poured information collected from various Government Agencies and from which computers could draw selected facts. It is our contention that if safeguards are not built into such a facility, it could lead to the creation of what I call 'The Computerized Man,' [who] would be stripped of his individuality and privacy" (Hon. Cornelius E. Gallagher, chairman of the subcommittee on Invasion of Privacy of the Committee on Government Operations, US Congress, 1966, p. 2). A climate of concern was kept alive by Congress because of the increasing rate at which computers were changing the lives of citizens and society. Jerome B. Wiesner (1915-1994), dean of science at MIT and former science adviser to President Kennedy said:

> The computer, with its promise of a million fold increase in man's capacity to handle information, will undoubtedly have the most far-reaching social consequences of any contemporary technical development. The potential for good in the computer, and the danger inherent in its misuse, exceed our ability to imagine [...] Our only hope is to understand the forces at work and to take advantage of the knowledge we find to guide the evolutionary process (US Congress, 1966, p. 5).

Fano tackled the ethical issues around computers' potentially negative impact on individuality and privacy (Chartrand, 2013, p. 182): from hacker attacks to bureaucratic controls. The community expected system designers to protect the integrity and privacy of their data against malicious action.

The general-purpose time-sharing system

From 1963 to 1969, the Project MAC policy for the creation of the Multiplexed Information and Computing Service (MULTICS), the successor to the CTSS, was headed by the representatives of the three institutions involved: Robert Fano for MIT, Edward E. David for the Bell Labs and John Weil for General Electric. This so called "Trinity" was supported by the "triumvirate," the technical committee that included Fernando Corbató for MIT, Ed Vance for General Electric and Vic Vyssotsky for the Bell Labs. In this period many were attracted by time-sharing systems and adopted computers as working tools. In fact, ARPA contributed to the sponsorship of the other six time-sharing systems, in 1964 in particular: the Carnegie Institute of Technology, Dartmouth, Stanford, and UCLA which led to commercial time-sharing operations. This work was the basis for commercial time-sharing MARK I and MARK II. (Reed, Van Atta, & Deitchman, 1990, p. 19).

In 1968 Licklider succeeded Fano as Project MAC's director, while Robert continued his work promoting computers. He participated in many conferences in Europe and the US. In so doing, his aim was to give an example of how information circulation and knowledge sharing could stimulate new research. Furthermore, his intention was to demonstrate the working strength of the new generation of time-sharing systems, the Multiplexed Information and Computing Service (MULTICS). Indeed, in October 1969 MULTICS became operational as a general-purpose system for multiple access designed for General Electric 645 in conjunction with Bell Telephone Laboratories. A new partner of MIT's, the Honeywell Information System, replaced the Bell Labs. The system was imperfect but it improved time sharing's management efficiency with a new technique, "program segmentation." Program segmentation used a new algorithm in use at MIT, named "paging," to manage the concurrency of programs into memory (Corbató, 1969). This algorithm could transfer pages of information between the main and secondary memories. When the size of a program exceeded the available memory, the program was divided up into pages, each made up of 1024 words, which corresponded to the size of logical blocks into which core memory was divided up. Pages were transferred into core memory only when needed, if at all. When a page was needed, the "supervisor," the system's main program, loaded it into the memory. If there was insufficient space, the supervisor removed another page from the memory. Then, "paging" answered the question: "Which page should be removed from core memory?" The MULTICS strategy was *Least-Recently-Used* (LRU), since it exploited the high correlation that linked the less frequently used pages to the less necessary pages in a running program (F. J. Corbató, 1969, pp. 217; 219).

With the LRU, individual tasks could be achieved with minimal use of precious memory space and "without having to waste too much core memory to store entire programs waiting to be executed" (*Ibidem*). In paging segmentation, segment information included a page table address for each segment. Individual segments had an associated set of permissions for authorized processes. In this way segmentation was also a method of implementing memory protection.

A further innovation in second-generation time-sharing systems was the data protection technique. The security system consisted in "protective rings," a series of levels which users could access with a personal password only. The levels created a limited area that safeguarded against both programming errors that could unintentionally open access to the whole system and deliberate attacks by criminals wanting to get their hands on space, data or other users' codes (Fano, 1967, p. 257).

Fano therefore envisaged the research undertaken bringing time-sharing systems to all production environments. These systems could change future work organization because they would allow the dominance of hierarchical structures to be overcome (Fano, 1967, p. 249). He also forecast a loss in meaning in concepts of centralization and decentralization for social organizations, since individual users would be able to directly coordinate their activities with their network of colleagues via time-sharing system tools (Fano, 1967, p. 259). In 1973, Honeywell issued a market product using the Honeywell 6180 hardware and MULTICS was installed at over 80 sites, but it was not very successful. Much more important was the influence that its design and many of its features had on modern commercial operating systems through the dissemination of a further operating system, UNIX. The latter inherited many of MULTICS's features because it was developed by two MULTICS programmers, Ken Thompson and Dennis Ritchie, from the Bell Labs. The latter wanted to create a simpler and more effective system for hardware with fewer resources (Van Vleck, 1995). Their success in this quest brought a large market share to UNIX which expanded in two directions: 1) into universities: a) Berkeley Software Distribution (BSD) from Berkeley University, from which NextStep and MacOS X originated; b) SunOs and Solaris from Stanford University; 2) the System III & V family. UNIX emphasized cooperative remote computer usage as Fano wished and BSD UNIX 4.2 was the first release to provide the tools with which to create a local network (LAN) (Frankston, 1996, p. 72). The effects of the computer utility concept were a split between computer systems' role as an object of research and development of theoretical research and their role as working tools. The former led to the UNIX operating system and the latter to mini computers and applications. The early 1970s pointed to the development of a billion dollars market in the computing utility industry, just as Fano had foreseen (Mahoney, 2008, p. 1).

As Corbató has stated, a continuity was established between MULTICS and UNIX because the first choices of the MULTICS Trinity influenced Thompson and Ritchie in their work on improving UNIX's functioning (Corbató, October 30, 2000).

Advanced Research Projects Agency NETwork (ARPANET)

Meanwhile, the interoperability introduced by time-sharing had incorporated computer use into interpersonal communications and entertainment and a new network project, ARPANET, was emerging in the public domain. In July 1968, during the MIT-Technical University of Berlin Computer Conference, the setup demonstrated how remote connection between the terminals in Berlin and a time-sharing computer at MIT worked. In 1969, the University of California in Los Angeles delivered the first Interface Message Processor (IMP), which would serve as the Network Measurement Center for the developing ARPA Network. In fact, in 1971-72, the MIT Project MAC MULTICS machine was connected to the ARPANET. In 1972 the first ARPANET hardware interface at Project MAC was set up between a Digital Equipment Corporation PDP-10 model KA (known as MIT-DM) and a Honeywell DDP-516 operating as an ARPANET Interface Message Processor. CTSS was turned off (Garfinkel, 1999, pp. 24-26).

The Tech Square, Project MAC's home, hosted the nodes of the MIT network, ARPANET's East Coast hub (MIT, 2004). It was the original Network 18, known today as mit.edu. The continuity between the Project MAC technologies and the Internet must be sought in the search for a symbolic representation of knowledge in order for this to be reusable. In fact, "from the opening of the Project MAC to the invention of the Web, unlike many other technologies, the network components and at last Internet were developed almost entirely in the academic world, based essentially on computer programs, that is, intellectual work" (Flichy, 2008, p. 28). This was just what Licklider and Fano had hoped for when they launched the computer access improvement program.

In 1973, Fano was appointed to the National Academy of Engineering for pioneering work in the development of the first interactive time-sharing computer system and his contribution to communication theory (Garfinkel, 1999, pp. 30-31). In 1975 Project MAC was renamed Laboratory for Computer Science. Fano's 1960s vision for MIT, which accorded computers a future in education, was therefore achieved, because a broad range of new disciplines was born to shape the new MIT original curriculum in Computer Science. In 1978 Fano was elected to the National Academy of Science.

In the early 1990s, the father of the Web, Tim Berners Lee, set up the World Wide Web Consortium's global headquarters on the third floor of Tech Square. The Computer Science Lab became a global reference point for theoretical formalizations and the exploration of new technological environments to keep young engineers up-to-date with society's needs. This had originally been MIT's mission, according to its founder William Barton Rogers (1804-1882), and the vision of Vannevar Bush as MIT vice president (Campanile, 2016, p. 32).

In 2003, the Computer Science Lab was merged with the Artificial Intelligence Lab to form CSAIL. From Building NE43, known simply as Tech Square, the Computer Science and Artificial Intelligence Laboratory moved its home to the Ray and Maria Stata Center. Fano loved this building because it represented freedom and creativity for the community (Fano, 2013).

Conclusion

Fano's research naturally poses a question: Could the interaction of users in time-sharing, namely mediated by computers, bring a positive impact on the wider society? Fano's answer was more robust than Bush's analysis since the former had already accepted the digital paradigm and foreseen computers' use as a medium of transmission. Fano was the first to recognize time-sharing's capacity to give humans control over computers to the extent of their being able to use them in a creative way and share ideas with them, beyond their mere capacity to compute information (Lee, Rosin et al., 1992, p. 35).

Fano's vision of technological progress was a positive one, in line with his determined and optimistic character and a historic period in which he affirmed "scientism," or rather a belief in science's ability to solve social problems. He thought that scientists, especially software designers, played an important role in society because they were guarantors of people's most valuable asset, privacy. It was the duty of scientists to build software capable of protecting individuals' information. In fact, the risk of an attack on individuality through the improper use of new technologies required the scientific community to act as one of time-sharing system's "rings of protection," that is, as a level of protection. It was scientists' duty to ensure that electronic automation was an advantage and not a danger to democracy and humanity.

This vision was obviously based on unconditional trust in two elements: the superiority of democracy over despotism and science's ability to overcome religious, racial, gender and cultural barriers. Science and democracy together led to a common goal, human good. These beliefs stemmed from the personal experience of successful emigrants and Project MAC's positive results.

Certainly, Fano could not foresee all the aberrations of communication through the "social media," which would have undermined Internet's democratic nature.

Through his personal social ties Fano directly demonstrated that a social network is formed when more people identify with common interests. His social network thus preceded the global physical network that was to connect up the world, the Internet. Fano himself loved to say: "I came during the electric engineering age and being here I created the Computer Science Age at the MIT" (Fano, 2013).

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zurück

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zurück

A Conversation on Network Histories

Yong Hu, Benjamin Peters

What is network history?

YH: There is no denying that networks have a clear technical meaning: through long-distance communications, they connect related but dispersive elements, be they human or non-human actors. At the same time, network is also a sociological term that refers to social relationships between individuals and relates to the frequency, distribution, uniformity and intimacy of such relationships. Talking about networks in a general sense inevitably leads to ambiguity and misunderstanding. This makes the study of network history a rich field involving clarifying questions, identifying problems and distinguishing differences.

The word "network" has had a powerful ontological meaning right from the start. Its characterization of the essence of things evokes a mental image not of a hierarchical space but a polycentric context, more precisely, it constitutes a topology change in complex self-assembled structures. When it comes to networking, two-dimensional plane thinking or even three-dimensional spherical thinking is impossible. You must realize that there are as many nodes as there are dimensions. This is extremely useful in understanding modern society, because the society we live in is porous, idiosyncratic, collaborative, with distended capillaries, and its properties can never be fully grasped in terms of layers, angles, boundaries, domains, categories, structures, and even systems. When we employ a network framework to critically analyze modern society, we are actually explaining the above-mentioned concepts, yet at the same time differentiating the ontology, topology and politics of those concepts. I believe that it is impossible to understand cohesive social factors without considering the social structure in terms of the facts produced by the natural and social sciences as well as the production of engineers. The only way to do this is to introduce the social, political, and cultural into the network concept.

Therefore, scholarship concerning network history must emerge from diverse disciplinary and methodological traditions, addressing a range of topics, touching on an array of purposes, and also exploring unchartered waters. The point of such work is not just to develop an overall abstract picture (a goal with very limited chances of success), but rather to remind us of the specifics of each situation and see how they compare with others in terms of the similarities and differences. This can help us reveal contrasting contingencies and different modes of practices, leading to a full appreciation of the political, social, economic, and cultural forces that drive today's network society.

BP: I largely share your vision here. I too see network history as an emerging interdisciplinary field of scholarly inquiry that is usually situated at the intersection of the history of technology, STS, communication and media studies. As this volume illustrates, it promises to be much more as well, intersecting *any* number of potential fields, including the history of business and transportation, political economy, sociology, cultural studies, surveillance studies, urban studies, policy, the philosophy of science, mathematics (networks as topological abstractions), and many others. Networks refer to more than just interconnected devices—they also employ the language of ecosystems, institutions, bodies, and other systems. Perhaps like all interesting topics, network history is bound to include whatever scholars make of it: the more diverse interdisciplinary interests scholars can bring to networks, the richer (and potentially more incoherent) the work will be.

Worth that risk, network history also comes with its own intellectual peculiarities. Namely, networks, unlike many other topics in media history and the history of technology, invite by their nature comparative and infrastructural analysis for one simple reason: collaborations bring networks into being. In other words, all sufficiently large networks exist thanks to preexisting cross-institutional collaborations and infrastructural arrangements. All attempts to build networks build on pre-existing means of coordinating interests across space, time, and society. No new media or computing network can exist, except upon the work of other supporting communication networks. As such, perhaps network history cannot help but be about the ongoing and uneven negotiation of disparate social interests. The history of networks is always already a history of certain kinds of collaboration—and once we have it clearly in our minds that the study of networks is the study of collaboration, the necessary cultural, social, economic, and political contexts you mention come more clearly into focus as well. Taking that peculiarity seriously poses significant intellectual and practical challenges to how scholars talk about networks.

It is also worth noting how frequently networks disobey the designers of their makers. Networks are puckish creatures—rarely do they do what their designers command them to do. Consider the curious fact that, in the age of the petabyte, two of the four largest telecommunication companies in the world still boast the word telegraph in their names (American Telephone & Telegraph and Nippon Telephone & Telegraph) while six of the largest ten claim telephone (AT&T, China Mobile, NTT, Vodafone, América Móvil,

zurück

Telefónica). Communication networks have, of course, enabled, speed, and helped generate forms of cultural and commercial creativity for generations. In fact, so essential is network access today that many pay their smartphone carriers before the local grocer. Gazing back on the humble origins of our communication networks, it appears obvious that networks have evolved in ways that no one, then or now, could have predicted. One of the most vital network history questions that strikes me, anyway, is to grapple with (admittedly loaded) questions like these: why do networks keep betraying their best intentioned designs? How and why did certain networks (and not others) transform telegraph wires over a century ago into global computer networks so "smart" they now trade in our thumbprints, profiles, and most intimate secrets without oversight or even much public awareness?

How do we talk about networks? How has network talk changed over time? What role do large countries—the US, China, and the Soviet Union, for example—play in those changing stories? How are network histories investigated in the US and China today?

YH: To begin with, it is important to avoid thinking of "the network" as a unified phenomenon. Measures of the extent of internet use may well be measuring very different things. The Internet includes a range of different technological affordances, social relationships, and cultural forms, each of which should be analyzed in its own right.

Any attempt to study even part of the network faces significant difficulties. The Internet is a decentralized medium that makes it impossible to fully understand all the aspects available online, let alone build a representative sample. This is a constantly changing medium that is always "under construction." As a result, any research must be considered "work-in-progress." Although it is rapidly evolving, network history still lacks shared descriptive and conceptual tools.

As far as the role big countries play is concerned, I would agree with Niels Brügger: "There are multiple local, regional and national paths and a variety of ways that the Internet has been imagined, designed, used, shaped, and regulated around the world." Chinese network historians must bear in mind that their subjects are non-linear and multimodal, they are expected to challenge monolithic and uncritical accounts, explanations and evidence, different cultural forms must not be discussed in isolation from each other, and finally, the Chinese internet is characterized by fundamentally different distinctions and demarcations than those typical of the "Western" internet.

For example, the party-state has implemented an active policy to promote a Chinese-centric web, making it into a cultural resource whose reach is circumscribed by the state. People living within "the Chinese intranet" seem to experience very different information flows and patterns of cultural consumption. Yet at the same time, Chinese netizens are creating a new political subjectivity that helps them lay claim to and bring to fruition their citizenship. This provides a vivid example of the interplay between the affordances of communication technologies and the way people utilize them for their own purposes.

Ben, you raise a very interesting point about the incompatibility between network design and network operations. Today's Chinese internet users are seldom aware that there used to be a backbone network called China Public Multimedia Network, more often known by its dial-up access number 169, as "169 Network." Back in the late 1990s, the Chinese government endeavored to develop Chinese-only versions of the Internet walled off from the rest of the world. "169 Network" did not provide direct access to the Internet which was restricted to internal IP addresses only, in order to deal with "the shortage of IP addresses, the threat of information security, the large amount of sexual and reactionary information, vulnerability to the attacks of hackers, and the language barrier (most of internet content is in English)." As you might imagine, this vast nationwide intranet did not last long.

BP: This is a key point. There is no single network. Although patterns may obtain, there is no universally typical network experience, as the Chinese intranet and early Soviet computer network cases make obvious.

It may be useful to inject a bit of historiographical contrarianism into much contemporary network talk. I would propose that a sure sign that the future of network history is bright would actually be the *decline* of the term in the present. In other words, it is a given that historians arrive at topics late in the game, or as Hegel put it, in the dusky flight of Minerva's owl. I take this to be, on balance, a good thing: historians should be able to discover much wisdom about the history of networks only after folks are no longer preoccupied with its vocabulary. (How else could wisdom appear except in distinction from the mainstream?) Buzz first, history later.

At the same time, I am not convinced that, at least in my circles, network talk is in decline. Take the term "network" itself: the English word, with origins in the lattice and lacework of pre-industrial England, has certainly enjoyed exponential traction over the twentieth century, picking up a trickle of attention in the interwar period and then spiking steeply since the rise of the internet in the 1980s and 1990s. The bulk of evidence suggests the term remains largely up in the air today: a search for "network" today uncovers headlines about the regular network fare of cable news, sports channels, telecommunication company updates but also intrigues in foreign cyber attacks, school consortiums, business connections, neuroscience, fungi colonies, and bitcoin currency mergers. The term is far from settled or over: for example, "mesh networks," a term of art for non-hierarchical computing connections as well as a return to the textile origins of the word, is a rather curious redundancy: what else could a network be but mesh? As Bernard Geoghegan has quipped in his own work on the programmable Jacquard loom, there may be more silk than silicon to the computing age, and still, we have a long way to go before network talk settles down.

What are the major challenges facing the writing of network history?

YH: As your point suggests, network historians must constantly revise their definitions of the field and their understanding of the historical dynamics. At the same time, as a new branch of the history of science and technology, network history has to develop new concepts, methodologies, and theories to explain what historians are witnessing right before their eyes. Moreover, they have to think about unprecedented topics such as cloud computing, data flow, cybersecurity and cyber warfare, digital platform, and artificial intelligence, to name just a few.

I actually think researchers should not give too narrow a definition of network history. The field should not be limited to computer networks per se, but also include histories of various network services (histories of BBS, blogging and microblogging, etc.), history of internet governance (Laura DeNardis' work on ICANN is a very fine example), the forming of digital subjectivity (for example, the term *netizen*, or in Chinese, *wangmin*—a portmanteau that literally means "a citizen of the Internet," originating from the U.S. and fast becoming hugely popular in defining China's internet users as though they were members of a "fifth estate," could characterize an interesting discursive approach to network history) as well as the emergence of online civil society (note that civil society has a number of theoretical models from which to develop analyses for particularities and localities). Also, the political economy of internet development should also be part of historiography, i. e., the origin of online public opinion, the evolvement of the concept of information sovereignty, the rise of digital economy and even a history of internet censorship.

Such broad questions require large-scale quantitative and qualitative research. Richer ethnographic research on the characteristics of users (even including non-users) would further aid scholars' ability to understand the long-term implications of online social life.

Another challenge would be, when we analyze network history, we must be specific and careful not to draw too broad conclusions. Today, as the

zurück

web has come to constitute an ever more ubiquitous social environment, it is becoming more and more difficult to grasp as an analytical totality.

BP: Here are two challenges for the network historian: one, pressing and political, and the other, conceptual. First, how did the distributed computer network—a technological approach to relations that first promised to bring about global democracy and liberty—end up enchaining the world in surveillance?

Second, here is the conceptual puzzle that eventually connects back to that first question: what is and isn't a network anyway? Perhaps, no one really knows what a network *is*. And harder still, no one really knows what a network *isn't*. In other words, we understand fairly well what makes communication networks work, but no one has an adequate accounting of what a network *is* or of the gaps that make it up. As I argue elsewhere, a network should not be mistaken for its network design, just as one should not mistake hiking a mountain trail for reading its map. "A map is not the territory," in founding semanticist Alfred Korzybski's famous line. Similarly, the documentable experience of a network territory (that is, of a set of assembled relations at work in the world) is far richer and broader than most talk about network designs (e.g., hubs, degrees of decentralization, link analysis, etc.). Network technologists tend to know what makes networks work (many specialize in precisely that). But, since network projects often rise or fall for reasons unrelated to the network itself, network historians may best account for what makes networks *not* work.

Thus, to understand the reasons networks often do not work, a historian should study the worlds they inhabit. Computer networks—because they both build on and, later, support unstable constellations of corporate, state, and institutional infrastructures in the mixed economies of the twentieth century—have proven particularly tricky muses of modern communication over the last fifty years; and there is both an insight specific to networks and a broader lesson to take from the tumultuous history of global networks: the broader lesson is that computer networks—like most technologies in history—consistently counter the fondest wishes of their designers. In the annals of technology, the dynamics of actual organizational behavior carry far more explanatory weight than the far more popular ideals of technological design. The history of networks focuses this general lesson to a specific point about collaborative projects as well: large communication networks, because they are by definition dispersed across many organizations, illuminate the profound power of institutional collaboration in practice, especially from the myriad reasons collaborative network projects do not take shape (Susan Leigh Star's and Thomas Hughes' diverse works on large technical systems are STS touchstones here).

There are, of course, many other more practical challenges that attend the writing of network history, although they are the usual challenges that come with writing history across multiple institutional sources. As you discuss, there is the challenge of defining and managing the scope of the project, which is always ongoing balancing act between not drawing too broad conclusions about the local experience of a network and its ubiquitous media environments (here the framing work of media scholar Christopher Ali on local media policy comes to mind); second, doing so in a way that encourages intellectual coherency around both your specific network project as well as distinctions from other types of network projects, which I think rehearses your point about continuously adjusting and adapting our understanding of what a network is and has been throughout history (perhaps the signal work for me is media historian Sebastian Giessmann's monumental *Die Verbundenheit der Dinge*); and most of all, the often hard-as-nails archival problem of actually accessing and synthesizing partial records distributed across the institutions that support whatever network you are researching. Many network histories, such as my own work on early computer networks in the Soviet Union, default to telling the story from the one or two primarily institutions that granted the researcher access; while this is sometimes inevitable and appropriate when framed as such, there is much to be gained from paying attention to the networks of (sometimes conflicting) records that result in building communication networks themselves: a recent signal network history, exemplary in its attention to globally diverse institutional sources, is historian Simone M. Mueller's *Wiring the World: The Social and Cultural Creation of Global Telegraph Networks* (New York: Columbia University Press, 2016). To twist a phrase from communication scholar Elihu Katz, international communication networks always precede national networks.

What are some of the major opportunities?

YH: Network history has become a research focus in the natural and social sciences, art and humanities, bringing distinct fields into conjunction (and sometimes confrontation) with each other.

Firstly, we could study the technology that comes from the basic architecture and infrastructure of the network. These are visible in the general network structure, the links, and the specific technological affordances of given tools and platforms. Secondly, social contingencies are embedded in user practices: a rich minefield of digital capabilities, usage patterns and networked social relationships. These contingencies can evolve as user practices change. Thirdly, the political and economic domains of the network will need a great deal of ongoing topographical mapping. For example, our attention could be drawn to the concentration of ownership and the privatization of the open Web, prosumer commodification, platform governance, as well as the evolving relationship between networks and states.

Bearing in mind that political economic dynamics tend to impact on both technical and social contingencies, shaping, for example, the character of specific applications and complex relations of reciprocity.

The past decade has been marked by many important changes in the development of the network, tools are multiplying, platforms prospering, and people's leverage and understanding of these tools and platforms are becoming routine, but all of these point to an unmistakable dynamic evolution toward a fundamental redefinition of the network that goes beyond tools and platforms to reach the core of social arrangements. We will face a conflict of what I called "the old regime vs. the digital revolution." It is for this reason that popular perceptions of and academic discourses about the Internet are shifting from "a longstanding emphasis on possibility, novelty, adaptability and openness, and toward current preoccupations with risk, conflict, vulnerability, routinization, stability, and control." (Leah A. Lievrouw, "The Next Decade in Internet Time: Ways Ahead for New Media Studies", Information, Communication & Society 15 [5]: 616-638, 2012)

This is what I think the basic dilemma of today's digital life is: there are so many people who care about digital wealth, yet so few people who are concerned with the fundamental issues arising in our digital society. Those issues in urgent need of action are complex and difficult, such as the conflict between privacy and openness, security and freedom, government snooping and personal autonomy, protection of intellectual property rights and promotion of creative activities, and the increasingly powerful network platforms and user rights that need to be more extensive.

In the context of all these conflicts, the most important thing is to return to the original starting point and try to figure out a key question: what is the Internet? This is a question that begins simple but becomes complex; it seems to have been answered but never got fully answered.

In my view, there are two ways to deal with this "network question:" first, conceptualizing it; secondly, imagining it.

What is the Internet? How do we understand this ubiquitous and familiar feature in our everyday world? What can the Internet do, and what is new among the things it can do? What new ethical, social and political capabilities has it triggered? Does it make things outdated, problematic, or even impossible? As the world around us continues to reorganize, the social-technical combination we call the Internet poses a key challenge to many of the familiar assumptions and imaginations that make up our presence.

The conceptualization of the Internet is based on what is known; our image of it is based on what we might reasonably expect to see in the near future and beyond. To this end, we need both new values theory (ethics and political philosophy) and new epistemology (theories about knowledge and science). Our thinking about the network will surely reach this final stage at some point: we will start wondering, in a fully networked environment, what constitutes a human? What is human nature?

BP: Many challenges are potential opportunities in need of a thorough rethinking—and networks deserve the full-court press of critical historical attention. Networks—precisely *because* they, once understood as historical objects, offer such challenging and uneven constellations of social and technical relations and power that now rankle the present-day (the surveillance and security issues around the internet of things, net neutrality, cloud computing, mesh networks, etc.)—carry the potential to offer tremendously rewarding for critical diachronic study. Networks now appear the background for the stage on which modern users play out ours lives—or as the choice lens through which contemporary media users most often view and frame our relations; we imagine ourselves, wrongly or rightly, to be linked, connected, and adrift amid uneven hubs of relations. No doubt much of this connectivist language is as useful as it is misleading and shortsighted! Perhaps modern media users should understand the nature of relations not through connection but, to take just one different approach in network history, through gaps, breakages, fissures, and dynamic openings (this resonates with the earlier call to attend to the collaborative social world that often produces network project "failures"). Other metaphors latent in the materials of network history could include the labor and the language of fishing and capture, lace and textile work, city sewers and infrastructure, broadcast channels and mass society. Amid much else, network historians are uniquely positioned to help the reading public rework these and many other differences between rhetoric and reality in the tangled documents of our networked past.

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zurück

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