4 Networks and the Social Imagination

> One can take issue whether the technical designs that emerge out of that [collaborative] process are the best possible, but it is far more important that they actually come into existence by a process that is open—architecturally open, politically open, that new people come in regularly, that the results are distributed free of charge around the world to everybody. The enormous power of those very simple concepts is very hard to convey to people who have not experienced them.[1]
>
> —Steve Crocker

WHEN CAN A person using a computer be said to be acting alone, and when are they acting with others? At first glance, staring at a monochrome screen and typing arcane commands to connect to and interact over a network is hardly different from configuring a spreadsheet on an Apple II. Both involve esoteric interaction with a machine and lend themselves to an obsessive absorption; both can have the effect of removing one's attention from the physically proximate person in the next room. But, in the United States in the 1980s, for those narrow circles of individuals involved in various stages of the early development of the internet, there were key differences between their experience and the experience of the millions who were encountering microcomputers, and those differences lent themselves to different possibilities for articulation with larger visions. If using a stand-alone microcomputer in the early days lent itself to a feeling of Lockean autonomy from others, using a computer network could have something of the reverse effect; working on a computer terminal connected to a network, particularly over time, foregrounds the social connections embedded in the technology. Anyone who has had to intervene in a discussion list or in a chat room to keep things going smoothly—by, say, giving technical advice to a newbie or by encouraging a flamer to moderate their tone for the sake of group harmony—has had a small taste of this effect. *Attention becomes directed towards the social mechanics of interaction within a system.*

One wouldn't have known it at the time by reading *Time* or *Fortune*, but, looking back, it is now clear that the 1980s was a time of great advancements in computer networking. While the U.S. mainstream was romancing the entrepreneurial tale of the stand-alone microcomputer in the 1980s, outside of the limelight, major developments were taking place with rather different political connotations. By 1980, packet switching was established as a practical means of communication both on the experimental internet and the working X.25 networks that connected banks and research labs. Ethernet (as well as competing token ring and ARCNET) local area networking technology became commercially viable, and the basic underlying protocols for today's internet, TCP/IP, were put into place, tested, and heavily developed. Commercial computer networks like Compuserve and Prodigy were launched, small computer bulletin board systems started to spread, and many university computer scientists began to communicate over the low-cost Usenet system. France led the world into consumer use of computer networks with its nationwide Minitel system, launched by the French post office, that allowed emailing and looking up information on terminals in the homes of citizens. For a substantial segment of the community of computer engineers, networking was near the center of their attention in the 1980s.

Because these events did not enter the broader public eye in the U.S. until a decade later, however, a broad discussion of what happened in the 1980s occurred only after the fact. And, as people have looked back to figure out where this amazing thing called the internet came from, the effort became an opportunity for much hagiography and not a little political mythmaking, both intentional and not. For example, in response to the common (if absurd) mid-1990s habit of attributing the rise of the internet to the free market,[2] Michael and Ronda Hauben published a series of articles and a book that made a strong case that the rise of the internet was due to antimarket, communitarian principles consistent with the 1960s New Left. Howard Rheingold and others in Stewart Brand's circle grafted computer networking onto the New Communalism. And numerous potted histories and timelines of the internet appeared in print and on the internet itself, often reflecting various political inclinations in their selection of details.

Since these early efforts, the discussion has matured, and a more serious historical literature on the evolution of the internet and computer communication has appeared. Works by Janet Abbate, Paul Ceruzzi, and James Gillies and Robert Cailliau have provided much finer detail and careful analysis.[3] But one of the striking things about this newer literature is that, while it is careful not to rush to impose political assumptions onto the historical detail, political questions keep resurfacing. The impact of the internet has been so large, and its origins so distinct, that one cannot help but wonder about the implications of this course of events for understanding politics and social relations.

Here I will focus on a few, illustrative episodes in the evolution of networking in the 1980s, with an eye on what makes them politically unusual and therefore intriguing. Previous work has demonstrated several important points. First, the internet most certainly was not created by two guys in a garage, by small entrepreneurs operating in a classic free market. It was developed inside Hughes's military-industrial-university complex—at a moment when that complex was undergoing significant changes. This fact alone serves an important rejoinder to market fundamentalists and libertarians. But it is also important that the larger development framework was that established by Vannevar Bush. Private corporations were involved in the internet early on and were for the most part always imagined to be central to whatever form the technology would take as it matured; the simple fact that early internet development was funded by tax revenues does not by itself confirm, say, a New Left position with regard to corporations.

Second, part of what distinguishes the early internet development from alternative networking efforts in the 1980s is an unusual culture of informal, open, horizontal cooperation—that very distinct set of practices that are incompletely summarized today under phrases such as "rough consensus and running code," and "end-to-end design."[4] The role of these practices in the history of the internet has become something of a political football; blessed by their genealogical relation to one of the major technological success stories of the twentieth century, they are claimed as supporting evidence by classic corporate liberals, libertarians, democratic socialists, and anarchists alike. It is important to get beyond the simplistic versions of these appropriations. Fred Turner has made the important point that friendly horizontal collaboration among engineers is hardly by itself a guarantor of political democracy broadly construed, and it is in fact historically consistent with autocratic and highly oppressive political structures, like the cold war efforts of the 1950s. And the history is clear that, to the extent there is a politics to internet development, it is not something that can be read off of the political concerns of particular engineers; right- and left-wingers, hawks and doves, all made important contributions, often in cooperation with one another.

This chapter reflects on two instances of a new and unusual set of practices that emerged around 1980, ways of social and technological organization that in retrospect seem relatively politically satisfying and practically effective. First, it looks at the development of new chip design methods in the late 1970s, which led to VLSI (Very Large Scale Integration) microprocessors in the 1980s. While not always listed in the chain of developments that led to the internet, the VLSI chip design process was key to maintaining the momentum of Moore's Law and set the conditions for the parade of ever-improving microprocessors and graphics chips on top of which the internet was built. For my purposes, it nicely illustrates the discovery inside computer engineering of the sheer technical value of attention to social process and to open, networked, horizontal relations. Second, the chapter discusses the much more clearly political economic moment during which the ARPANET efforts were split off from the military and quietly transferred to NSF funding. What is distinct about this remarkable moment is, not just the spirit of openness, but the use of that kind of open collaboration to carefully shepherd a developing network as it passed outside of the cocoon of DARPA funding into a wider, more fraught world of funding by an ever-growing variety of users and sponsors. Theoretically, packet-switched global computer networking could have come to us in any variety of institutional packages, but this 1980s experience of quietly guiding the growing internet into a space between the differently charged force fields of military, corporate, university, and NSF funding left a stamp on the institution of the internet that would have far-reaching consequences.

"We Don't Have to Form Some Institute": The Case of Lynn Conway and VLSI Chip Design

There was never a single justification for seeking to communicate between computers. In the 1960s and 1970s, funding sources were the military and large corporations, so command-and-control uses were favored, such as building a communications network that could survive a nuclear attack, controlling military operations at a distance, or distributed use of centralized supercomputers for scientific research. These are the ideas that dominated grant proposals, committee testimony, political speeches, and mainstream newspaper coverage. But other ideas percolated in the background, such as Licklider's, Engelbart's, Van Dam's, and Nelson's grand dreams of interconnected communication machines.

But the eventual triumph of the ideas of Engelbart was as much a product of surprising experiences with early forms of computer communication as it was a matter of persuasion by a few intellectuals. The most often-mentioned surprise discovery of the ARPANET was the popularity of email and discussion lists; built for command-and-control uses, the ARPANET turned out to be a great way to just chat, and the numbers of emails over the network skyrocketed.[5] These statistics, coupled to the fact that most of the people reading the statistics had personal experience with email themselves, gave substance to the ideas of the likes of Engelbart and Nelson. By the late 1970s, among computing professionals, the idea of using computers for communication between people was no longer abstract; it increasingly had an experiential grounding.

At least as important as the sheer fact of email's popularity was its social tone. Some of this was simply about the informal styles that became customary on email. For example, in 1978, Licklider and a colleague noted:

> One of the advantages of the message system over letter mail was that, in an ARPANET message, one could write tersely and type imperfectly, even to an older person in a superior position and even to a person one did not know very well, and the recipient took no offense. The formality and perfection that most people expect in a typed letter did not become associated with network mes-

sages, probably because the network was so much faster, so much more like the telephone. Indeed, tolerance for informality and imperfect typing was even more evident when two users of the ARPANET linked their consoles together and typed back and forth in an alphanumeric conversation.[6]

It is probably not inherent to computer communication that it encourages informality. It may be simply that, when email started to spread in the late 1970s, the secretaries who were regularly taking hand-scrawled notes on yellow pads and turning them into formal letters were not the ones typing emails. Networked computers were still too rare, expensive, and hard to use to integrate them into the established rituals of the office. The social institutions and expectations that ordinarily lend themselves to formality—secretaries, letterhead, the legal expectations that go with a signed letter—were not operational.

But the informality of online communication was also associated with something more subtle that started to become part of the experience of those using networked computers: the occasional efficiencies gained when working online on technical projects as a group. People often mention the surprising popularity of nontechnical discussion lists in the early days, like Usenet's alt.culture.usenet and alt.journalism.criticism.[7] But the fact is, well into the 1980s, computer communication was predominantly communication about computers; the majority of email and discussion list use was about technical issues.

This might seem like a criticism, but significantly, for the people who designed and built computers, this could be a surprisingly effective way to get things done. An early and influential version of this discovery occurred when Xerox PARC scientist Lynn Conway and Caltech professor Carver Mead collaborated on the development of VLSI design methods for microchips in the 1970s. Carver Mead, credited by Gordon Moore with coining the term *Moore's Law,* was the first to use the methods of physics to predict the theoretical limits of the capacities of microchips. By the early 1970s, these predictions made it clear to Mead and others that individual microchips, especially microprocessors, were destined to become bewilderingly complex. Intel's first microprocessor, the 4004, contained 2300 transistors on a single chip; this was a lot for the time, but it was still something that could be designed by a relatively small team in a matter of months. But, recognizing that this was just the beginning of a trend, Mead foresaw that, as the number of transistors per chip increased logarithmically, this would create new design challenges. How would the complexity of design be handled as the capacity of single chips reached hundreds of thousands, or millions, of transistors?

Lynn Conway, an expert in computer architecture who had made some pioneering innovations at IBM in the 1960s, teamed up with Mead to tackle this problem; as she put it, he was approaching the problem from the level of silicon upwards, and she was approaching it from the level of software downwards. The significant thing about their approach was that they did not set out to design a particular chip or even a particular type of design; they set out *to design a method of design*, a way to make accessible and better organize the process of VLSI microchip design. The problem, as Conway described it in a 1981 presentation, was that

> when new design methods are introduced in any technology, especially in a new technology . . . a lot of exploratory usage is necessary to debug and evaluate new design methods. The more explorers that are involved in this process, and the better they are able to communicate, the faster the process runs to any given degree of completion. . . . How can you cause the cultural integration of the new methods, so that the average designer feels comfortable using the methods, considers such usage to be part of their normal duties, and works hard to correctly use the methods? Such cultural integration requires a major shift in technical viewpoints by many, many individual designers. . . . The more designers involved in using the new methods, and the better they are able to communicate with each other, the faster the process of cultural integration runs. . . . New design methods normally evolve via rather ad hoc, undirected processes of cultural diffusion through dispersed, loosely connected groups of practitioners, over relatively long periods of time. . . . Bits and pieces of design lore, design examples, design artifacts, and news of successful market applications, move through the interactions of individual designers, and through the trade and professional journals, conferences, and mass media. . . . I believe we can discover powerful alternatives to that long, ad hoc, undirected process.[8]

What's distinct here is the extent to which Conway, while working on what she called "designing design methods,"[9] is explicitly talking about *social*, as opposed to purely technical, processes. It's worth emphasizing that Conway is no computer impresario or pundit like George Gilder or John Perry Barlow, who basically make use of the technological for political or social purposes; she is a true engineer working at the cutting edge of her field, giving a talk at Caltech to other engineers. Yet her primary concerns are numbers of individuals, their communication skills, and their culture. She describes her work from this period as a "new collaborative design technology."

Mead and Conway's widely used textbook on VLSI design was not just a summary of what people were already doing; it was carefully thought out to enable more people to participate in the process of microchip design, and was written more with an eye to where microchip design was going than to where it was at the time. Once they had developed some basic ideas about how to simplify the process of design, as Conway put it, "Now, what could we do with this knowledge? Write papers? Just design chips? I was very aware of the difficulty of bringing forth a new *system of knowledge* by just publishing bits and pieces of it in among traditional work. I suggested the idea of writing a book, actually of *evolving a book*, in order to generate and integrate the methods." So the textbook was not just released into the world on its own; it was developed in the context of a series of courses, beginning with one Conway taught at MIT and later extended to several other academic centers of high-tech development, where each course served simultaneously as a way to spread the new ideas and as a way to improve them through tight interaction and quick feedback between everyone involved.

"Perhaps the most important capital resource that we drew upon," Conway states, "was the computer-communications network, including the communications facilities made available by the ARPANET, and the computing facilities connected to the ARPANET at PARC and at various universities." The initial drafts of the textbook used in the first courses, she says, "made use of the Alto personal computers, the network, and the electronic printing systems at PARC" so that they could see the inside of a classroom and be modified based on experience before needing to go through a publisher. Student designs were transmitted over the ARPANET from MIT on the east coast to PARC on the west coast for relaying to a fabrication plant. As the courses expanded to other major universities, the network was used to coordinate the multiple efforts so that all students' projects could be transmitted to PARC for quick and cost-efficient fabrication.

"The networks," Conway observes,

> enable rapid diffusion of knowledge through a large community because of their high branching ratios, short time-constants, and flexibility of social structuring; any participant can broadcast a message to a large number of other people very quickly. . . . If someone running a course, or doing a design, or creating a design environment has a problem, if they find a bug in the text or the design method, they can broadcast a message to the folks who are leading that particular aspect of the adventure and say, "Hey! I've found a problem." The leaders can then go off and think, "Well, my God! How are we going to handle this?" When they've come up with some solution, they can broadcast it through the network to the relevant people. They don't have to run everything through to completion, and then start all over again, in order to handle contingencies. This is a subtle but tremendously important function performed by the network. . . . Such networks enable large, geographically dispersed groups of people to function as a tightly-knit research and development community. . . . The network provides the opportunity for rapid accumulation of sharable knowledge.

Participants in these courses took these experiences and went on to fund startups (like Jim Clark, who used his course design to create Silicon Graphics [SGI] and then from there went on to found Netscape) and to build the chips that fueled the continued growth of the computer industry throughout the 1980s into the 1990s.

Other communities of computer professionals were having similar experiences. The pioneers of the Unix operating system, which would eventually come to be the most common operating system on machines that ran the internet, also discovered that there were technical strengths in systems that were designed to lend themselves to communication and collaboration. One of Unix's designers, Dennis Ritchie, famously wrote of the motivation for creating Unix: "What we wanted to preserve was not just a good environment in which to do programming, but a system around which a fellowship could form. We knew from experience that the essence of communal computing, as supplied by remote-access, time-shared machines, is not just to type programs into a terminal instead of a keypunch, but to encourage close communication."[10] Beginning at Bell Labs in the early 1970s, Ken Thompson, Ritchie, and others developed a series of practices that went beyond just particular algorithms, software code, or techniques. Their basic vision of how to approach computer development was distinct. Instead of a company or handful of engineers developing a full-fledged system and then offering it for sale to users—the norm for IBM and other companies at the time—Unix provided what came to be known as a programming environment, where each function was rendered as a separable bit of software that could run on a variety of hardware and was flexible and easily linked to other programs through "pipes." (The famous example here is Unix's search function, grep; instead of building search functions into specific programs like word processors and email applications, grep can search within files from the command line, can be easily connected to other functions, and is thus available for other programs to use; it was an early instance of what became known as a software tool as opposed to a complete program.) Usenet, the legendary early bulletin board system that was the first introduction to computer bulletin board communication for many outside those few that were connected to the ARPANET, was created in 1979 for Unix users at universities to more easily collaborate on Unix-related projects.

Not the least in these efforts was the evolution of the culture of development and governance structures around the ARPANET. The ARPANET was intended from the outset to work across different computer platforms within different institutions, and the procedures for developing the protocols for connecting disparate systems was left largely to the institutions themselves; no single individual or institution was assigned the task of telling everyone else how to interconnect. As a result, a culture and shared awareness developed in the first decades of the internet's life that took into account the need for, and value of, an open, collaborative, nonhierarchical decision-making process. A symptom of this was the creation of the tradition of gently named RFCs (Request for Comments) as the central mechanism for distributing information about the rules and protocols for networking computers over the ARPANET. Out of a few initial meetings attended largely by graduate students, an organization called the Network Working Group was formed (predecessor to today's IETF, which continues to play a key role in the evolution of internet technical standards). This community developed the habit of what has been called "rough consensus and running code," design efforts driven by a loose consensus among expert insiders that is then closely tied to widely shared, practical implementations. Steve Crocker, who as a graduate student wrote the first RFC and who as of this writing remains involved in internet governance, said in 2006,

> One can take issue whether the technical designs that emerge out of that process are the best possible, but it is far more important that they actually come into existence by a process that is open—architecturally open, politically open, that new people come in regularly, that the results are distributed free of charge around the world to everybody. The enormous power of those very simple concepts is very hard to convey to people who have not experienced them.[11]

To illustrate just how deeply (if not widely) the habit of thinking about computer networks as a means to establish horizontal communication for the purposes of technological development had become, it is useful to consider the case of Lynn Conway's move to DARPA in late 1982. Because of the success of her work at Xerox PARC, Conway was recruited to join DARPA to help oversee the newly formed Strategic Computing Initiative (SCI). The project had very conventional Reagan era cold war goals coupled to a Vannevar Bush-style theory of technological innovation; DARPA's official project summary said it would develop technologies, "for such military purposes as aircraft carrier command and control, photo interpretation, and strategic target planning,"[12] while much of the enthusiasm for funding the project in Congress was based on the theory that it was the U.S. answer to Japan's Fifth Generation Computing Initiative, which threatened the United States's technological and, by extension, economic superiority.

By taking this job, Conway was demonstrating that she was no antiwar liberal. (In response to critics, she has said, "if you have to fight, and sometimes you must in order to deal with bad people, history tells us that it really helps to have the best weapons available.")[13] But Conway carried a sense of computers as tools for horizontal communication that she had absorbed at PARC right into DARPA—at one of the hottest moments of the cold war. At the time, she described her goal as fostering collaborative technical development over computer networks, telling a reporter,

> We don't have to form some institute. Wherever people are they can participate. . . . We'll need to have some workshops and some establishing of interfaces among these groups. . . . And then, we'll cook up some network activity. . . . DARPA is to the Department of Defense as the Palo Alto Research Center is

> to Xerox. . . . There's a kind of spirit that approaches passion that arises when researchers are forging ahead in new territory. . . . I'm going to try real hard to make some interesting things happen with [DARPA's] money. . . . It greatly oversimplifies to say that we're out to produce a machine. . . . Any one machine is only one point in the design space. . . . You'll see a whole array of technologies and knowledge spin off from the DARPA work. If the work is sufficiently successful, it will have all sorts of applications. . . . [Within 10 years] I imagine that you are going to see a wave of start-up companies as a result of the DARPA-funded research.[14]

The notion that defense research could and should lead to commercial spin-offs was conventional corporate liberalism, in the vein of Vannevar Bush. What is distinct is Conway's style and her enthusiastic description of computer networks as a forum for horizontal collaboration; where her predecessors in the military-industrial complex would have at least gestured to a command-and-control vision of computer development, particularly in a military context, she was speaking frankly and almost exclusively of the value of opening the research process up to relatively informal forms of interaction, to "cooking up some network activity."

The Strategic Computing Initiative is known to some as an expensive failure,[15] and Conway left DARPA after a few years to teach at the University of Michigan. What is significant here is simply that, even in a classic military-industrial context, a computer scientist was speaking a different language about how to make sense of the social relations that undergird technological innovation: "We don't have to form some institute. . . . We'll cook up some network activity. . . [to encourage] a kind of spirit that approaches passion." This is language that would not have been used even by the likes of Engelbart or Licklider in the 1960s.[16] Even deep under the military umbrella, the tone of computer engineering had changed.

In sum, the invisible colleges of computer professionals attached to big institutions like Bell Labs and research universities entered the 1980s already in the habit of thinking seriously about the *specific social organization* of the process of building new technologies, heavily inflected with an interest in creating contexts for effective collaboration and a sense of how hierarchy and institutional allegiances can interfere. Many of the key individuals had specific experiences of cases where open collaboration and the sharing of technical information over computer networks could create efficiencies. Thinking about "designing design methods" was becoming a habit, and easily accessible computer networks were being used as a tool for that purpose. While the rest of the world was dazzled by the stand-alone microcomputer and its association with free market individualism, the communities of computer networkers, who still largely lived out of public view inside the narrow worlds of the university-military-industrial complex, were having experiences that pointed in other directions.

The Internet's Institutional *Annus Mirabilis:* The Split from the Military in 1983–1984

If Conway exemplified the microstructure of the new network-inflected habits of thinking about the organization of technological development, the fate of the internet in the 1980s reflects a more macro-oriented version of those ways. The practical experiences with the subtle effects of the social conditions of technological innovation were essential to internet decision making in the 1980s. Part of this was simply the discovery of the values of allowing open interconnection. The more participants on a network, the more satisfying the experience of using the network was. Researchers in both public and private settings with access to the ARPANET thus regularly began to allow new participants access to the network, often quietly so as to avoid repercussions from administrators still viewing networking through a command-and-control lens.[17] Alternative, more bottom-up networks like Usenet began to create gateways to the much more privileged and previously exclusive ARPANET.

The story of the internet's relation to the Strategic Computing Initiative illustrates how unusual this kind of reasoning was at the time. SCI was new money, and a lot of it; over its lifetime a billion dollars was spent. The principal creator of SCI was Robert Kahn, then head of DARPA's IPTO and one of the key figures in the creation of the ARPANET in the late 1960s and 1970s. While hopes of science-fiction-like new military applications and besting the Japanese helped wrest this funding from Congress, Conway and the other leaders of the program had a somewhat broader vision in mind with SCI, something that would extend the DARPA tradition of seeding bold, exploratory developments in computing in a way that would advance the entire field. It thus attracted the interest of many researchers throughout the world of computing, from artificial intelligence researchers to solid state physicists interested in new principles for semiconductor design. This was classic Vannevar Bush-styled technological development.

Yet what is striking about the internet in this period was that its leaders *chose* to forgo SCI funding. In particular, Barry Leiner, at the time the program manager of the ARPANET for the Pentagon, specifically declined an invitation to participate in SCI. One might think that internet developers would have jumped at a chance to be involved, particularly given that SCI was under the leadership of one of their own, Robert Kahn. (And anyone who has been involved in the academic pursuit of research funding will note how unusual it is for an ambitious researcher to turn down any funding opportunity.) But Leiner has said that in the early 1980s he was more concerned with avoiding public attention associated with the high-profile SCI than with resources. Funding was less of a problem for the ARPANET at the time, particularly since the desire to interconnect computer networks was now becoming strong among researchers, which meant that many of them—including those involved in SCI—would bring their own resources to the table. SCI's high profile, however, might also bring with it public controversy and meddling, and Leiner's judgment was that such visibility would outweigh whatever benefits could be gained by more funds.[18]

The goal, moreover, was not to be simply secretive or exclusive. In 1980, when ARPANET's Vint Cerf met with a group of computer science professors from across the country, he offered to connect the ARPANET to a proposed academic research network if it adopted TCP/IP protocols.[19] This set the trend towards encouraging open access to the internet, which would become the informal policy throughout the 1980s, leading to dramatic growth fueled, not by lots of government funding, but by an individual institution's desire to interconnect. By the mid-1980s, ARPANET managers Cerf and Kahn were informally encouraging institutions to connect their Local Area Networks—the then-new technology of LANs that interconnected groups of workstations and microcomputers—to the ARPANET. This was a tactic that proprietary systems would be loathe to pursue, but it had the effect of initiating the period of logarithmically increasing internet connection numbers.[20]

The policy towards openness then gradually filtered into the small *p* political world. While avoiding the limelight by staying away from SCI, Leiner also famously shepherded in a new governance structure for the ARPANET that, at least formally, "was open to anyone, anywhere in the world, who had the time, interest, and technical knowledge to participate."[21] Time and technical knowledge were of course major limitations on participation, but those limitations were defined by practical involvement in the technology instead of position in one or another institutional hierarchy. It was a striking bit of openness quietly emerging from near the heart of the military-industrial complex at a very conservative moment in the country's history.

Leiner's decision is a symptom of a subtle sense of the sociology of network innovation and governance that had been evolving inside the community of those working on building the internet, a sense that seems to have influenced much of the decision making in internet development and that contributed to the internet's eventual triumph. Kahn later said that Leiner's "ability to understand how to create social and organizational structures that by their design could motivate individuals to collaborate was at the core of this important contribution" to the creation of the internet.[22] But Leiner was not alone in this ability. From experiences with things like Unix, Usenet, VLSI, and the ARPANET, Leiner and his colleagues had developed an awareness of the value of an informal, committed, open, participatory community environment. That awareness, however, was associated with a corresponding sense of ways that external pressures and agendas could undermine that environment. Corporate profit imperatives, politics, fads, egos, and bureaucratic rivalries could all interfere, at the exact same time that these things generally also provided the context that kept the money flowing. This sense of potential threats and possibilities was driven by accumulated experience and a deep involvement with the technology, not by political inclinations or theories, which meant that it worked at an often not-quite-explicit level. The occasional incorporation of countercultural style, the tolerance of informality, the dodging of hierarchies were not driven by any consensus about 1960s New Left politics; as the case of Conway reveals, the politics of the participants could be quite diverse. But the experiences of the 1960s did become part of the background shared experience of the participants and were drawn upon whenever they might have seemed useful for achieving the goal of widespread computer networking. The community had learned that, in some cases, "we don't have to form some institute."

That shared sense helps explain one of the more remarkable events in the 1980s history of internet development, the separation of the ARPANET into civilian and military parts, which helped lay the foundation for a subsequent civilian, nonprofit, working internet. In October of 1983, the military split the ARPANET into linked but separate military and civilian networks. Most press reports explained this as driven by fears of potential security breaches by hackers breaking into military computers.[23] The nonmilitary, more open network, it was thought, would support militarily significant research; the first reports of the split said the new, nonmilitary network would be named R&Dnet. (It is significant that the name R&Dnet did not stick; the community seems to have understood the "new" network as simply a continuation of the ARPANET and its traditions, while the military branch was seen as something else.) As BBN vice president Robert D. Bressler put it matter-of-factly, "the research people like open access because it promotes the sharing of ideas."[24]

The noteworthy aspect of this move, however, was not that the military requirements of hierarchical command-and-control eventually came into conflict with the growing culture of open collaboration around the ARPANET. That alone would have been unsurprising. Rather, the important point was that the military-centered leaders allowed the creation of a separate, open network for research and development; they kept the internally open system of the ARPANET alive rather than simply shutting it down or subjecting it to more severe access limitations. The technology could have been passed on through publications and transfer of personnel; that was the textbook way to conduct a military-to-civilian technology transfer. But in this case the people involved (most centrally Cerf, Leiner's predecessor at DARPA, and his closest colleagues) understood the social commitments and energy that would come from keeping an established, working, and growing network going and managed to quietly carve out a safe space for that network within the pressures that typically come with funding sources. The fact that this event is typically described in the literature and by participants as if it were a technical matter suggests that the sociological sense that was driving decision making in the community at the time was taken for granted. By the end of 1983, a platform for highly effective inter-networking was in place that was protected from the divisive pressures of the profit motive by the mix of military and university contexts and funding, while also fairly well-insulated from the political and technical demands that drove so much of government activity at the time. As if by historical accident, an unusual and what we now know to be enormously productive technological space was created.

The next step in the divorce from the military context was shifting funding to the National Science Foundation, which was accomplished with remarkably little friction or rivalry, no doubt due in part to the astute, under-the-radar style of the key participants. By the second half of the 1980s, a backbone for TCP/IP interconnecting was being constructed called the NSFNET. The internet could from then on be treated as a more generalized research project. To the rest of the world, this all looked like scientists and engineers just doing what they do. That it was something more than that, that in fact an interesting political experiment was underway, would only begin to become apparent at the close of this period, around 1990.

The Information Superhighway: Al Gore, Jr., and the NREN

As 1990 approached, strict market-based economic policy seemed to be on the wane, domestically at least. The stock market crashed in 1987—the first such crash in the United States since 1929—and Silicon Valley was threatened by the Japanese, particularly in the area of memory chip manufacture. The wide-open, unfettered free market was looking a little less inviting and a little more threatening to significant groups of business leadership. As a result, for executives, the business press, and many politicians, a principled hostility to government seemed a little less appealing. Corporations were quietly moving away from the rhetoric of competition and back towards asking for government help to organize and stabilize industries, with calls for regulations that provided "level playing fields" and "regulatory backstops."[25] Some representatives of high-technology industries began calling for government coordinated "technology policy," which was a vague term for the use of government to provide things like tax incentives, research money, and antitrust waivers.[26] Technological progress, many were beginning to believe, could not be left up to the market alone. Explicit forms of corporate liberal cooperation were coming back in fashion.

In the worlds of computing and high technology in the late 1980s, many who were scanning for the next wave—the next best thing after the microcomputer—were finally looking towards networking, but most were imagining things happening in a more collective, centralized way; if there was going to be a digitalized, networked future it was going to be a cooperative project. It was not going to come out of garage start-ups but would involve some form of consortia, private/public coordination and partnerships. Indicative of the trend was the formation of General Magic by a consortium of computer companies in 1987, and the formation in 1989 of the Computer Systems Policy Project, a lobbying group made up of the CEOs of ten computer manufacturers, including AT&T, Digital, Hewlett Packard, and IBM.[27]

Similar impulses were driving efforts in networking. As the network—now increasingly called the internet—continued to grow and possible commercial uses began to come in sight in the late 1980s, things seemed to be going according to formula. In 1988, computer scientist Leonard Kleinrock chaired a group that produced a report, "Toward a National Research Network"; this report caught the attention of, among others, Al Gore, Jr. In May 1989, the Federal Research Internet Coordinating Committee, released a "Program Plan for the National Research and Education Network," which proposed, after an initial government investment in a high-speed network backbone to major computing sites, that subsequent stages "will be implemented and operated so that they can become commercialized; industry will then be able to supplant the government in supplying these network services."[28] That same year, physicist and former IBM vice president Lewis Branscomb teamed up with Harvard-trained lawyer Brian Kahin to found the Information Infrastructure Project (IIP) at Harvard's John F. Kennedy School of Government, with funding from a rich mix of foundations, government agencies, and corporations.[29]

The tone was high minded and acronym-laden—National Research and Education Network quickly became NREN—with an emphasis, as per the title, on applications like education and scientific research. "The NREN," it was proposed,

> should be the prototype of a new national information infrastructure which could be available to every home, office and factory. Wherever information is used, from manufacturing to high-definition home video entertainment, and most particularly in education, the country will benefit from deployment of this technology. . . . The corresponding ease of inter-computer communication will then provide the benefits associated with the NREN to the entire nation, improving the productivity of all information-handling activities. To achieve this end, the deployment of the Stage 3 NREN will include a specific, structured process resulting in transition of the network from a government operation a commercial service.[30]

Drafts of legislation began circulating in Congress, proposing federal funding for a network that would "link government, industry, and the education community" and that would "be phased out when commercial networks can meet the networking needs of American researchers."[31]

Many readers will remember all the talk about the "information superhighway" in the early 1990s. Because of the rich mix of political and economic energy to which the phrase became attached, it developed a lot of momentum. Politicians sought to ride on its coattails, and industry factions began to try to capture it; phone companies claimed they could provide the information superhighway, provided the government stayed out of it, thank you, and the cable industry countered by politically correcting the name of their newest technology from "500 channel TV" into "cable's information superhighway."[32] *Information superhighway* became so common it sprouted its own metaphorical universe, involving phrases like "road kill on the information superhighway."[33] It's easy to forget, however, that for the first few years of this buzzword's flourishing, the information superhighway was not necessarily the internet.

The phrase *information superhighway* has been around since at least the early 1980s and the metaphor of an information highway for at least a decade before that.[34] But around 1990, *information superhighway* began to take on a very specific life inside the political circles of Washington, DC. At the time, the U.S. economy was floundering, and the administration of George H. W. Bush was looking increasingly helpless on the economic front. *Fortune* magazine sniped that "the President has been disengaged, reactive, and inarticulate" on the economy.[35] The Democrats in Washington sensed an opportunity; the slogan "it's the economy, stupid" would soon prove devastating to Bush in the next election. But the problem for the mainstream Democrats was finding a way to differentiate themselves from the Republicans without opening themselves up to the label of tax-and-spend liberals that had been used so successfully against them in the previous decade by Ronald Reagan.

In the 1950s, Senator Albert Gore, Sr. had made a name for himself by shepherding in the interstate highway system, which gave a huge boost to the auto industry and the economy in general while profoundly shaping American life and culture around the automobile. It was one of the most successful and beloved massive U.S. government building projects of all time, a triumph of corporate liberal habits. To this day it stands largely above criticism. No doubt this rousing success was somewhere in the back of then-Senator Albert Gore, Jr.'s mind when, starting in 1988, he decided to get involved in building computer networking in the name of research. Gore, Jr.'s inspiration was to link up with various proponents of advanced computer networking in the engineering community, sponsor legislation that funded the development of a state-of-the-art computer network of networks, and call the project the "information superhighway."

The idea pressed several buttons at once; the high-tech industries, battered by Japanese competition and nervously groping for the next wave, looked favorably upon this modest kind of government investment, which after all could save them the cost of a lot of high-risk R&D and perhaps shield them from overly intense competition. Because the project was wrapped in the glamorous aura of high technology and a positive vision of the future, Democratic politicians, like Gore, Jr. himself, could use this safely as a model of "good" government intervention, undermining the Republicans' efforts to maintain power by associating Democrats with government bureaucracy and excess. And it appealed to a kind of economic nationalism; by 1991, a Congressman argued for government involvement in the creation of a U.S. broadband network by saying "the Japanese will have an information superhighway by the year 2005 and the USA won't."[36] Small wonder, then, that Gore, Jr.'s bill moved calmly through both houses of Congress and was signed by President Bush in 1991, providing for 2.9 billion dollars over five years for building the NSFNET.[37] At the time, Al Gore noted, "in many ways, this bill is very unusual. I have been working on this bill for more than 2 years, and almost no one has said a discouraging word about it. Instead, I hear enthusiastic support in many, many different quarters—within the administration, in the telecommunications industry, in universities, in the computer industry—among researchers, teachers, librarians, and many others."[38] And then in 1992 the election of the first Democratic president in more than a decade seemed to make the political climate favorable for this kind of public-private effort. This looked like a classic implementation of Vannevar Bush's corporate liberal principles for technology development.

The Public/Private Problem and Com-Priv

But the Bush philosophy does not always lead to the linear, orderly process it is sometimes imagined to.[39] Corporate liberalism mixes private and public, and for all its historical effectiveness, that mixing creates a substantial grey zone where the rules are unclear and asks the polity to take a lot on faith about both the good motives and the wisdom of the individuals at the center of this movement between the two worlds. And it inevitably raises the question, why should private companies and individuals profit from publicly funded research? Why is this not government favoritism?

Bush himself squabbled with President Truman and Congress in 1945 over the exact form that the National Science Foundation was to take. One Congressional bill, for example, proposed that all patents for the government-funded research be retained by the government, whereas Bush favored protecting private patents out of concern for maintaining flexibility and autonomy.[40] Bush's approach was based on a deep faith in the capacity of scientists, engineers, and other experts to overlook their own selfish interests in the name of reason and progress. The Congressional proposal, by contrast, was based on a more transparent, skeptical logic. The fact remains that the process of transfer and public/private cooperation in general involves neither a Lockean market nor a public process dedicated solely to the public good. It is a movement between different worlds that operate by different rules. There is no getting around the fact that research efforts paid for at least in part by public tax money come to serve the interests of those who are making a private profit.

These tensions were laid bare on one of the more lively and revealing public political economic discussions of the early 1990s, a now-legendary discussion list called the Commercialization and Privatization of the Internet—com-priv for short. The community of network experts, having spent the 1970s and 1980s simultaneously developing the technology, discovering its pleasures, and learning the value of an open approach to its coordination, did what to them was the obvious thing; when faced with the sociopolitical complexities of making the internet into something broadly available, they established an electronic discussion list, open to all with the means and interest to sign up—which at the time, was still a relatively narrow circle.

Com-priv was initiated by Martin Schoffstall, a long-time participant in the Internet Engineering Task Force who had recently founded a company called PSI to offer access to the internet on a commercial basis. Opening his initial post to the list with the address "GentlePeople," Schoffstall laid out some questions: is the open, casual, RFC-based process of decision making adequate for a commercial environment? What will be the relationship between existing, tax-funded, nonprofit network providers and commercial newcomers (at that time, PSI and a company called Alternet)? What happens when commercial activities start taking place on noncommercially funded systems? Schoffstall concludes the post in a way appropriate to the inviting, informal tone that had become the norm in behind-the-scenes internet decision making: "Come let us reason together. . . . Marty."[41]

Some of the discussions that followed remained technical (for example, "How long does the UNIX password encryptor take on an 8088? Is it faster or slower than a PDP-11?").[42] But one of the striking things about the list is how much of it is devoted to working through policy issues; engineers found themselves thoughtfully debating fundamental principles of political economy. Much of the initial discussion began around something called the acceptable use policy (AUP).[43] After the transition from a defense department umbrella to the NSF, the network had evolved around the central, NSF-sponsored TCP/IP backbone called NSFNET, which was then connected to a variety of regional networks, most of which were nonprofits and often leased equipment from for-profit companies. High-tech corporations like BBN and Hewlett Packard, with their interests in networking and computer research in general, had various kinds of connections. PSI and a company called Alternet had begun offering access to the system on a commercial basis. The NSF portion of the network, however, was governed by a policy that said the network should be used only for appropriate research and education purposes.

With regards to the Acceptable Use Policy, Schoffstal asked, "How does one constrain use of federally subsidized networks . . . from doing commercial things?" Allen Leinwand, then a network engineer working for Hewlett Packard, elaborated on the problem:

> This question has plagued us here at HP for some time. . . . Suppose that HP connects to AlterNet (we have not . . . yet) and we now have the ability to pass commercial data across AlterNet legally to company X and company Y who are HP business partners. We are already considering the idea of subsidizing our critical business partners with the funds to connect to AlterNet when we do. . . . The main problem is how do you convey to about 90,000 employees that it is legal to conduct commercial business with IP based services to company X and Y because they are on AlterNet, but don't do it to company Z because they are only on BARRNet (the Bay Area public regional)? . . . I cannot really envision a network tool which intelligently decides what data is for commercial use and what is not. How do we distinguish between HP divisions working with the OSF across NSFNET (which IS legal) and the same division (or machine!) sending data to company Z?[44]

The subsequent discussion of this issue came up with more examples and explored different possible solutions. A purely technical solution was discussed, where different uses get coded into the network routing system, but it was generally deemed impractical because of the already quite blurry lines between nonprofit and for-profit activities on the network. Something that involved collective human decision making was needed. The problem was, in essence, political.

Political, but not polemical. The discussion on com-priv made the goal of a fluid, easy-to-use, open, and reliable network a priority above all else. Schoffstal, who had recently stepped into the role of an internet capitalist, wrote,

> What PSINet has been doing (and from all appearances what ALTERNET has been doing) is working with industry and not upsetting the stability of the non-profit mid-levels from providing service to the non-profits and academics. That non-profit infrastructure seemed pointless to hurt since too much of the US is incredibly dependant on it. . . . Now when the non-profits provide service to industry is where we get into a sticky philosophical/legal/taxation areas.[45]

Neither Schoffstal nor others tried to resolve issues by adopting principled antibusiness or antigovernment ideological positions that are so common in other public debates. Parts of the system that worked, in this case run on a nonprofit basis, were best not to be interfered with, even by for-profit entities. The approach was highly pragmatic.

But there was the matter of what Schoffstal called "philosophical/legal/taxation areas." Pragmatism around strictly technical matters is one thing, but pragmatism when it comes to the murky world of political and institutional structure is quite another. In the latter there is no getting around the fact of political and social choice; decisions will have to be made that will allocate and shape the distribution of power and resources, and no legal or technical necessity will dictate the form of those decisions in a completely neutral way.

Conventional corporate liberal decision making in the United States has generally dealt with these moments by couching things in the language of expertise, bound together by reference to the national interest or public good. When Herbert Hoover set out to organize the new technology of radio on a corporate for-profit basis in the 1920s, he gathered together a mixture of captains of industry and engineers and used the language of "the public interest, convenience, and necessity" to justify the creation of an administrative agency (predecessor to today's FCC) that proceeded to use government legal power to allocate radio frequencies in a way that favored large, well-funded, commercial operations. When tax money was used to create the interstate highway system in the 1950s, the legitimating language was that of national defense. In each case, the public language was highly formal and bureaucratic.

The tone on com-priv was something different. Instead of falling back on the authority of expertise and institutional hierarchy, there was an explicit small *d* democratic impulse: "come, let us reason together." That impulse was leavened by small gestures developed in past pragmatic experiences with such forms of decision making. Most of these gestures were tokens of informality: first name modes of address, occasional colloquialisms and personal details, and the use of self-mockery. Schoffstal, in describing an individual whose "position was a bit stronger than I would have taken" quickly adds a parenthetical aside, "(hard to believe for some of you)." All these gestures worked to soften personal sharp edges, generate a tone of informal solidarity, and facilitate group process.

United by the common goal of a functioning network, then, the community on com-priv was using what had worked for them in technical areas—free flowing, horizontal, electronic communication—to self-consciously deal with issues that were both philosophical and political. Tinged by (if not fully committed to) a post-1960s suspicion of established, formal institutional habits and by a corollary trust in informal directness, they set out to negotiate the blurry terrain between government and for-profit rules of operation in a manner that at that point in history was unique. They took what worked in a technical context—rough consensus and running code—and set out to apply it to matters that were becoming increasingly political.

In the broader political world, however, other habits dominated. In December of 1992, President-elect Bill Clinton convened a Conference on the State of the Economy, having made fixing the economy a centerpiece of his campaign. The conference brought together a blue-ribbon group of experts and corporate chieftains. At this point, the rhetoric of the information superhighway was in full swing, and so it was on the agenda, which gave Vice President-elect Al Gore, with his experience in setting the stage for NREN, a chance to shine on one of his favorite topics.

The *New York Times* quoted this exchange between Gore and AT&T chair Robert E. Allen. Allen said,

> A focus on infrastructure, including information networks, commercial networks which are interconnected, interoperable, national and global, needs to be encouraged. I have some points to make about who should do what in that respect. I think the government should not build and/or operate such networks. I believe that the private sector can be and will be incented [sic] to build these networks, to enhance them and make it possible for people to connect with people and people with information any place in the world.
>
> I do think, however, that the government role can be strong in the sense of first, increasing investment in civilian research and precompetitive technologies. Secondly, supporting the effective transfer of that technology to the private sector. Thirdly establishing and promulgating technical standards, which are so important to be sure that networks and devices play together, work together, so that we have the most efficient system in the world. And incentives for investment and research development, job training.

Gore replied:

> I fully agree when it comes to conventional networks and the new networks that your industry is now in the process of building. But with an advanced network like the National Research and Education Network, it does seem to me that government ought to play a role in putting in place that backbone. Just as no private investor was willing to build the interstate highway system, but once it was built, then a lot of other roads connected to it, this new very broad band high capacity network most people think ought to be built by the federal government and then transitioned into private industry. You didn't mean to disagree with that view when you said government should play a role did you?

To which Allen responded, "Yes I may disagree."[46] The next day, *USA Today* reported on the exchange under the headline "AT&T's Allen Feuds with Gore."[47]

There's a point of view that sees this dispute as merely technical. Gore and Allen both agreed with the basic Bushian approach in which government funds initial research and then hands things off to private industry for practical development; the question was simply about whether the initial backbone for a proposed high bandwidth network should be government-created and then handed off to industry or built by the private sector from the beginning. Brian Kahin, who was already staking out a coordinating role in this effort through the Kennedy School's Information Infrastructure Project, later complained that the Gore-Allen exchange "confused the issue." As far as he was concerned, everyone already assumed that the internet would be "opened up to the private sector." The network already was being built from the bottom-up by private entities—companies and universities—providing local area networks and workstations; the government was just providing some help near the center, with some "top-down subsidies." Private companies like IBM and MCI had already gotten government contracts to build significant parts of the technology, and in some cases, according to Kahin, they gave bids below costs, presumably because they viewed this as an R&D investment.[48] For someone like Kahin, all this was simply reasonable coordination of public and private efforts; concerns about the public internet being "turned over" to private enterprise were much ado about nothing.

But ado there would be. Ambivalence about the appropriate relations between government and for-profit enterprises are woven into the American soul. The Gore-Allen exchange would be just the first in a sporadic series of public squabbles revealing uncertainty over the boundaries between the private and public status of the internet in the years to come. Some of these squabbles would be mounted by political activists of various types; anticorporate activists would complain about the theft of public goods, and economic conservatives would try to prove that Al Gore (and public funding) had nothing to do with the success of the internet. But, even for those with less specific political agendas, the Gore-Allen exchange raises deep questions: who decides these things? Is it right that someone like Allen, with obvious corporate loyalties, be allowed such influence over this level of decision making? And was Al Gore's vision of a supportive government investment as cleanly rational as he made it out to be?

Looking back on his leadership in developing legislative support for the NSFNET, Gore said during the 2000 campaign for U.S. president, "I took the initiative on the internet." This statement was then attacked in print by libertarian *Wired* magazine reporter Declan McCullough and eventually twisted by various Republicans into the sound bite that Gore said he invented the internet.[49] From there it went on to become a favorite joke of late night comedians and a punch line in a TV pizza ad. It was a false slur, and it was irresponsible of reporters and politicians to repeat that sound bite up to the end of the campaign; it seems plausible that the "Gore said he invented the internet" quip did at least as much damage to Gore's final vote count as Ralph Nader.

But what's important about this episode is that, while the sound bite was factually untrue, it was funny. And it was funny because it appeals to a common skepticism about the orderly, managerial mode of thought associated with technology policy like Gore's. As far as Washington was concerned, the NREN was consistent with traditional corporate liberal policy; it was to be a technology test bed, something that would provide innovations that would eventually be implemented and broadly deployed by the private sector. And it would develop on a national basis, neatly coordinated by orderly consortia of established corporations like IBM and AT&T, perhaps eventually linking up with equally orderly systems developing in other nations around the world. It was all very high-minded. The information superhighway predicted by Gore's NSFNET initiative would be used by scientists for sophisticated research and perhaps as a kind of electronic library where thoughtful patrons would quietly and studiously gather useful information.

Gore did take the initiative on the internet, but what he had in mind was hardly the chaotic, explosive phenomenon that would soon be conveying a cornucopia of pornography, pop culture, conspiracy theories, and irrational exuberance throughout the globe. And he did not have in mind the kind of gently self-mocking, open, deliberative process that was taking place on com-priv.

Conclusion

To what extent did the habit of attention to social process that evolved in the 1980s matter in the history of the internet? In the early 1980s, the eventual triumph of the internet, especially of the TCP/IP protocol developed for the ARPANET, was by no means foreordained. Numerous other experimental networking efforts were running at the time, such as Britain's SERCNET (Science and Engineering Research Council Network), the French Cyclades network that inspired some of the techniques that had been brought into TCP/IP, and proprietary packet-switched internetworking systems provided by computer manufacturers such as DEC's DECNET. Most prominently, the X.25 networking standard, which was working commercially at the time and had the support of international bodies and telecommunications carriers, was considered by many to be the obvious wave of the future. In France, the PTT brought networking to common people with Minitel, whereas in the United States, networking remained largely buried away inside universities and the military-industrial complex for most of the 1980s. Minitel and other teletex systems seemed to many like the obvious way to bring digital communication to consumers. The conventional international body for setting technical standards, the ISO, was working hard at developing a global packet switching protocol called OSI, in theory more advanced than the internet's TCP/IP.

Moreover, by 1980, the cold war consensus that had given urgency to ARPA/DARPA in the 1950s and 1960s was gone. When the newly elected Reagan administration engaged in some high-tech saber rattling in the form of the Strategic Defense Initiative, the computer networks at Xerox PARC hummed with expressions of opposition, and a network discussion list was formed in October of 1981, which in 1982 lead to the creation of Computer Professionals for Social Responsibility (CPSR). The group became internationally prominent for their opposition to Reagan's SDI (popularly known as Star Wars), which was based on the theory that high technology—backed by the latest computers—could be used to shoot down enemy ICBMs. The program was not only destabilizing and likely to be perceived as a belligerent threat, CPSR argued, but it would not work because of the fallible nature of computing. In sum, the full intensity of the day's most heated political disputes had appeared within the still tiny world of computer networking. Some, like Conway and Kahn, still felt it was legitimate to engage in weapons-related research, but that choice was no longer taken for granted. The easy combination of social with military visions characteristic of Licklider's early work could no longer be assumed.

So why did the internet succeed? As with all technological standards, one has to allow for a certain amount of dumb luck: of accidents of timing, economics, or politics. The Betamax vs. VHS story is a favorite example; the adoption in the United States of the mediocre NTSC standard for color television in the early 1950s is another. One needs to take seriously the possibility that many or most of the reasons for the internet's eventual success over other standards and systems are simply ones of historical accident. One commonly offered explanation for the success of the internet's TCP/IP standards, for example, is simply money and timing. Buoyed by defense department funding into the 1980s, the internet's TCP/IP standards reached a critical mass of effectiveness and users at a time when other standards, notably OSI, were still struggling to achieve financial support and political and technical stability. Had some historical accident slowed the internet down or sped OSI up, the argument goes, internetworking may have followed a quite different path.

That said, in retrospect, clearly something was done right in the 1980s, and that something was not purely technical; it was not just the adoption of the specific technologies of packet switching and end-to-end design in the abstract. There are some political lessons to be learned from the success of the internet.

Most obviously, the internet was not turned into an effective communications medium by two guys in a garage, by corporate leadership, or by real or imagined market demand.[50] The free market visions and entrepreneurial fables that caused American culture to obsess over the microcomputer in the 1980s also created a blind spot that for the most part rendered invisible the collaborative, social institutions that created the internet. To a large degree, the context for the creation of the internet was defined by nonprofit institutions using government funding, with participation by the private sector, by individuals consciously working in a collaborative mode who valued freely sharing information and code within the technical community. Whatever one makes of those processes, they were definitely not entrepreneurial or market driven in any obvious senses of those terms—and the broad public ignorance of that fact would have substantial consequences in the 1990s.

But what, exactly, were those processes? One can find individuals of many stripes among the computer pioneers of the 1970s and 1980s who still draw divergent political conclusions from the period. Hauben and Hauben's *Netizens*, written during the 1990s as a critique of the marketplace enthusiasms of the time, would have the lessons of Unix and ARPANET development point towards the value of an antimarket communitarianism. Yet Steve Crocker, for example, has been involved in several commercial start-ups; he apparently does not see a fundamental incompatibility between valuing a system in which "results are distributed free of charge around the world to everybody" and private enterprise. If there is a dominant view amongst engineers, it is probably still some version of Vannevar Bush's: technological innovation requires a mix of public and private efforts, where the pattern is for nonprofit institutions to do basic research and perhaps establish shared frameworks and protocols, which are then passed on to private industry for development into working systems. Conway, for example, has repeatedly emphasized the ways that her work at PARC and later have fed into the creation of private start-ups and qualifies the collaborative sense of what was going on by calling it a "new kind of collaborative/competitive environment."[51] And, in the end, it must be acknowledged that there is a relative autonomy of engineering; engineers who work together are focused above all on getting complicated things to work, and that imperative seems to be able to create cooperation among engineers with quite different social and political proclivities.

Part of what happened was that, for key networking pioneers in the 1980s, attention to social, institutional, and political relations became increasingly folded into their technical concerns. In roughly the same way that learning a foreign language often makes one more aware of the grammar of one's native language, the act of building computer networks made one more aware of social relations. Diverse individuals and institutions established effective technical gateways between networks, developing protocols that allow different machines to interoperate, and similar tasks brought many of the material complexities of communication to their awareness. This was not without its pleasures, furthermore. Over time, the network grew, creating a situation where logging in always brought with it the possibility of new members of the discussion list, new connections and gateways to other networks—to new people, new social contacts. As the networking pioneers became more experienced with these fundamentally social aspects of networking, some of them eventually became involved in national legislative affairs, international regulatory debates, and some unique struggles inside the military-industrial complex. Out of the broad public eye, they laid the foundations for what would become today's internet, both on the technical level and on the level of political habits of governance.

In 1983, the to-that-point largely informal, open, democratic culture of early internet governance and technological development was given crucial institutional support. What could have been a minor aberration in the history of military-funded computing was instead nourished and encouraged so that it would eventually provide the technology and ethos that would lay the foundations for today's internet. It would be another decade before the internet would explode on the global stage and overtake numerous corporate efforts to popularize computer communication, becoming the vehicle for the realization of the long dreamed-of multipurpose global network. But the Department of Defense's 1983 decision to support a packet-switched network free from military command hierarchies was a key moment in creating the conditions in which open TCP/IP packet-switched networking was able to gradually evolve into the all-pervasive internet.[52] A community of researchers already attuned to the values and pleasures of decentralized computer networking and informal, horizontal means of governing the evolution of the technology through RFCs and voluntary committees was given the funding and legitimacy necessary to further cultivate the network outside the immediate pressures of both military hierarchies and the profit imperative.

The previous discussion suggests that the decision was as much a product of the culture of the community of computer engineers as of specific institutional needs or designs. A large part of what would come to triumph with the explosion of the internet is a particular vision of what computers are—writing technologies, devices for manipulating and communicating symbols among equals—associated with a particular kind of informal social vision, a set of beliefs about human social relations. That vision first appeared in the late 1960s at least partly under the influence of the 1960s counterculture, quietly grew through the 1970s, and by the early 1980s had sufficient influence to shape decision making within the Department of Defense. That vision is neither monolithic nor self-evidently politically generalizable. But the 1983 decision in particular illustrates the extent to which key decision making about network organization has been shaped as much by the cultures of the relevant communities of innovators as by macrostructural and economic forces.