Review Essay

Wizards, Bureaucrats, Warriors, and Hackers: Writing the History of the Internet

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TAKE A LOOK AT THE STANDARD TEXTBOOKS on post–World War II America. You will search in vain through the index for references to the Internet or its predecessor, the ARPANET; even mentions of "computers" are few and far between. The gap is hardly a unique fault of these authors; after all, before 1988, the *New York Times* mentioned the Internet only once—in a brief aside. Still, it is a fair guess that the textbooks of the next century will devote considerable attention to the Internet and the larger changes in information and communications technology that have emerged so dramatically in recent years. Few will share *Wired* publisher Louis Rossetto's hyperbolic claim that the digital revolution presages "social changes so profound their only parallel is probably the discovery of fire."[1] But most historians will feel compelled to reckon with the emergence of the Internet as a standard feature of everyday life.

How will that history be written? Four recent works offer some clues by addressing the history of the Internet from different perspectives (biographic,

My thanks to Steve Brier, Josh Brown, Deborah Kaplan, Mike O'Malley, and the anonymous readers for the *AHR* for helpful comments on an earlier version of this essay. The *AHR* will be posting links to the web sites mentioned in these notes on the World Wide Web at www.indiana.edu/~ahr/.

[1] Quoted in David Hudson, *Rewired: A Brief and Opinionated Net History* (Indianapolis, Ind., 1997), 7. I checked the indexes of the following seven books for references to "ARPA," "ARPANET," "computer," "IBM," or "Internet," and only found references to computers (but not the Internet) in the Schaller volume: William H. Chafe, *The Unfinished Journey: America since World War II*, 3d edn. (New York, 1995); Otis L. Graham, Jr., *A Limited Bounty: The United States since World War II* (New York, 1996); George Donelson Moss, *Moving On: The American People since 1945* (Englewood Cliffs, N.J., 1994); Frederick F. Siegel, *Troubled Journey: From Pearl Harbor to Ronald Reagan* (New York, 1984); Joseph Siracusa, *The Changing of America: 1945 to the Present* (Arlington Heights, Ill., 1986); Michael Schaller, Virginia Scharff, and Robert D. Schulzinger, *Present Tense: The United States since 1945* (Boston, 1992); Howard Zinn, *Postwar America: 1945–1971* (Indianapolis, 1973). Historians have been far from alone in ignoring the Internet. Although Microsoft claims that it had begun to develop an Internet strategy in 1994, its 1994 edition of *Encarta*, its multimedia encyclopedia, does not include the word "Internet." (It does briefly mention the ARPANET, although the entry is considerably shorter than the one for "Gates, William Henry, III." For pre-1988 coverage, see David Burnham, "Reagan Seeks Drive to Raise Productivity of U.S. Agencies," *New York Times* (February 20, 1985): A18. The Internet got its first real notice in the mainstream media in November 1988 when Robert Morris's "virus" temporarily shut it down: John Markoff, "Author of Computer 'Virus' Is Son of N.S.A. Expert on Data Security," *New York Times* (November 5, 1988): A1. For a perceptive counter to the utopian language that often surrounds discussions of the Internet, see Philip E. Agre, "Yesterday's Tomorrow" (1998), available on the World Wide Web at http://dlis.gseis.ucla.edu/people/pagre/tls.html (a slightly different version was also published in the *Times Literary Supplement*, July 3, 1998).

bureaucratic, ideological, and social) and considering different sources for the "creation" of the Internet—from inventive engineers and solid government bureaucrats to the broader social context of the Cold War or the 1960s. Although the Internet may be heralded as an entirely novel development, its historians have generally followed some well-worn paths in the history of technology. These conventional approaches are often illuminating, but the full story will only be told when we get a history that brings together biographical and institutional studies with a fully contextualized social and cultural history. The rise of the Net needs to be rooted in the 1960s—in both the "closed world" of the Cold War and the open and decentralized world of the antiwar movement and the counterculture. Understanding these dual origins enables us to better understand current controversies over whether the Internet will be "open" or "closed"—over whether the Net will foster democratic dialogue or centralized hierarchy, community or capitalism, or some mixture of both.

"CONTEXTUALIST" APPROACHES HAVE LONG DOMINATED academic studies of the history of technology, but narratives of "great men" of science and technology remain popular, deriving their power both from widespread assumptions about new ideas emerging from particular men of genius as well as from the narrative appeal of biography.[2] The title of Katie Hafner and Matthew Lyon's well-written and extensively researched work of popular history, *Where Wizards Stay Up Late: The Origins of the Internet*, neatly inscribes the book's great man approach. So does the dust jacket, which promises "the fascinating story of a group of young computer whizzes . . . who . . . invented the most important communications medium since the telephone."[3]

Hafner and Lyon begin their tale of "origins" with Bolt Beranek and Newman (BBN), the computer consulting company that had the initial contract from the Advanced Research Projects Agency (ARPA) for what became known as the ARPANET. (Founded in 1957 in the post-Sputnik panic over Soviet technological prowess, ARPA, a Defense Department unit, supported research and development in technology, particularly military-oriented systems such as ballistic missile defense.) The book's prologue describes a reunion of ARPANET's designers at BBN in 1994. This narrative choice and the centrality of BBN to the entire book owe a great deal to the study's origins in a suggestion from BBN, which opened its archives to Hafner and Lyon and even helped fund the project.[4]

Having started with the contractor, Hafner and Lyon explain the source of the

[2] For reviews of the historiography, see, for example, John M. Staudenmaier, *Technology's Storytellers: Reweaving the Human Fabric* (Cambridge, Mass., 1985), which argues that at least half the articles in *Technology and Culture*'s first two decades of publication take a "contextual" approach; and Stephen H. Cutcliffe and Robert C. Post, eds., *In Context: History and the History of Technology: Essays in Honor of Melvin Kranzberg* (Bethlehem, Pa., 1989). For a perceptive overview of writing in computer history, see Michael S. Mahoney, "The History of Computing in the History of Technology," *Annals of the History of Computing* 10, no. 2 (1988): 113–25.

[3] Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late: The Origins of the Internet* (New York, 1996).

[4] BBN did not, however, exercise any control over the actual book. I have used the abbreviation ARPA throughout this essay, but, in fact, it later became the Defense Advanced Research Projects

contract with another story. As they tell it, Bob Taylor, the head of the ARPA office that dealt with computer research (known as the Information Processing Techniques Office), faced an "irksome" problem in the winter of 1966. The room next to Taylor's office housed three computer terminals, each connected to a mainframe running at a different site funded by ARPA. Since the different terminals used different computer systems, program languages, and operating systems, they required different login procedures and commands. "It became obvious," Taylor later remembered, "that we ought to find a way to connect all these different machines" and, thus, share extremely expensive computer equipment. "Great idea," his boss responded. "You've got a million dollars more in your budget right now. Go."[5]

After Taylor gained funding for his project, he turned to "a shy, deep-thinking young computer scientist ... named Larry Roberts," who was "blessed with incredible stamina" and "had a reputation for being something of a genius," to "oversee the design and construction of the network." In 1967, at a meeting in Ann Arbor, Wes Clark of Washington University came up with the crucial idea of making the network function by inserting a sub-network of smaller computers between the host computers and the network lines—what later came to be called Interface Message Processors, or IMPs. Riding to the airport in a cab, Clark told Roberts that only Frank Heart could build such a network at a reasonable cost. Heart, too, is a wizard: "intensely loyal" and "nurturing," he has "prodigious energy" and the ability to make "certain that jobs he signed up for really got done." And with his help, BBN, the Cambridge consulting company where he worked, snared the million-dollar contract to build the ARPANET. (When BBN won the contract for the Inter*face* Message Processors, Senator Edward Kennedy sent them a famous telegram congratulating them on the "ecumenism" of their planned work on the "Inter*faith* Message Processor.")[6]

But why begin with Taylor and BBN? Many popular narratives of the rise of the Internet start earlier and with a story that is more grounded in a particular historical context. A widely distributed "Brief History of the Internet" by science fiction writer Bruce Sterling opens: "Some thirty years ago, the RAND Corporation, America's foremost Cold War think-tank, faced a strange strategic problem. How could the US authorities successfully communicate after a nuclear war?" The solution, as Sterling explains it, emerged in 1964 from the Rand Corporation and particularly from engineer Paul Baran, who imagined a network with no central authority, which "would be designed from the get-go to transcend its own unreliability."[7] Unlike a centralized network in which destroying the central switching point brings down the entire structure, Baran theorized that a distributed

Agency (DARPA) and in 1993, it became ARPA again. A key initial focus of ARPA was space exploration, but that work was soon spun off into NASA.

[5] Hafner and Lyon, *Where Wizards*, 12–13, 42.

[6] Hafner and Lyon, *Where Wizards*, 44, 25, 74, 92, 102; Peter H. Salus, *Casting the Net: From ARPANET to Internet and Beyond* (Reading, Mass., 1995), 34.

[7] Bruce Sterling, "A Brief History of the Internet," *Magazine of Fantasy and Science Fiction* (February 1993), but found on the World Wide Web at www.forthnet.gr/forthnet/isoc/short.history.of.internet. This account is also conventionally given (albeit sometimes in garbled form) in the many technical manuals on the Internet. See, for example, *The Internet Unleashed 1996*, 3d edn. (Indianap-

network could sustain multiple hits and keep working through alternative channels. Crucial to Baran's distributed network was his second key innovation, using digital technology to break up messages into discrete pieces that could be sent individually and then reassembled at the end point—a feature that builds more reliability into the system and makes more effective use of communications lines than telephone circuit-switching technology. (Telephone circuits set up a dedicated line between two people through which a continuous transmission is sent; if the participants turn silent for a minute, they still continue to use the circuit. "Packet-switching networks" are much more efficient because the data are broken into smaller chunks, which can flow through multiple paths and also share the same lines with other pieces of data.) British physicist Donald Davies, who later developed some similar networking ideas, gave Baran's "message blocks" the name "packets"—a rubric that has stuck today and is embodied in the notion of "packet-switching networks"—the core technology of the Internet.[8]

Starting with Baran instead of Taylor roots the Internet in the darkness of the Cold War rather than the bright idea of a clever engineer and emphasizes surviving (or fighting) nuclear war rather than sharing computer resources. His work, Baran later told an interviewer, "was done in response to the most dangerous situation that ever existed." Like his contemporary at Rand, Herman Kahn (the model for "Dr. Strangelove" in the Cold War satire that appeared the same year as Baran's report), Baran thought the unthinkable—how to carry on after a nuclear apocalypse. "If war does not mean the end of earth in a black-and-white manner," Baran wrote, "then it follows that we should do those things that make the shade of gray as light as possible: . . . to do all those things to permit the survivors of the holocaust to shuck their ashes and reconstruct their economy swiftly."[9]

Hafner and Lyon do not ignore Baran, but they downplay his significance as part of de-emphasizing the military origins of the Net even while they make clear that Baran's ideas were crucial in the development of the ARPANET. They credit Baran with putting in some of the Internet's "blocks" and "stones" but not with being its "architect." Roberts himself later put Baran more in the center of things, noting that when he read Baran's reports in 1967: "suddenly I learned how to route packets. So we talked to Paul and used all of his concepts and put together the [APRANET] proposal."[10] But the real point for Hafner and Lyon is about intentions, not credit; the ARPANET, they insist, "embodied the most peaceful

olis, Ind., 1995), 10, which begins its history of the Net with the heading: "From the Cold War—A Hot Network."

[8] On Davies's work, see Martin Campbell-Kelly, "Data Communications at the National Physical Laboratory (1965–1975)," *Annals of the History of Computing* 9 (1988): 221–47.

[9] Hafner and Lyon, *Where Wizards*, 56. On Rand and Herman Kahn, see Fred Kaplan, *The Wizards of Armageddon* (New York, 1983), 220–31. *Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb*, dir. Stanley Kubrick (1964).

[10] Quoted in Arthur L. Norberg and Judy E. O'Neill with contributions by Kerry J. Freedman, *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1986* (Baltimore, Md., 1996), 166. According to Taylor, he was initially unaware of Baran's work, but Janet Abbate pointed out that "Baran's ideas quickly entered networking discourse and practice" and that Baran "discussed his ideas with many computing and communications experts and his report was widely read by others." Abbate, "From Arpanet to Internet: A History of Arpa-Sponsored Computer Networks, 1966–1988" (PhD dissertation, University of Pennsylvania, 1994), 27.

intentions to link computers at scientific laboratories across the country so that researchers might share computer resources . . . Arpanet and its progeny, the Internet, had nothing to do with supporting or surviving war—never did."[11]

Starting with Taylor's effort to connect disparate computers, Hafner and Lyon weave a lively tale of the origins of the Internet. But their biographical focus slights the technical and intellectual (as well as the military) roots of the ARPANET experiment: the influence, for example, of work on time-sharing computers (machines set up so that they can be used at the same time by multiple users), small-scale computer networking projects, and the larger vision of giving people access to the world's knowledge—a heritage that runs from Denis Diderot's *Encyclopédie* to H. G. Wells's "world brain" to Vannevar Bush's "memex" to J. C. R. Licklider's "libraries of the future."[12] By de-emphasizing the social and political contexts in which the Net was built, Hafner and Lyon tell a story that most engineers would like—a tale of adventurous young men motivated by technical curiosity and largely unaffected by larger ideological currents or even narrower motives of self-advancement or economic enrichment.

Given their interest in the engineers and in BBN, Hafner and Lyon devote most of their book to a fast-paced narrative of the design and building of the system. They excel at explicating technical matters for a non-technical audience. But their coverage trails off after they describe the first public demonstration of the ARPANET at the International Conference on Computer Communication in Washington in October 1972. Although that event established the feasibility of packet switching, success at this point was limited. No one had really figured out what the network was good for; as late as the fall of 1971, network traffic was barely 2 percent of what it could potentially handle; it was, as Hafner and Lyon nicely put it, "like a highway system without cars."[13]

THE BIOGRAPHIC, GREAT MAN MODEL stretches Hafner and Lyon's literary talents, in part because the Internet lacks a central founding figure—a Thomas Edison or a Samuel F. B. Morse. It resulted more from bureaucratic teams than inspired individuals. Bureaucracy, however, rarely makes for lively reading. A bureaucrats' story unfolds with great care and mastery, though little excitement, in *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1986* by Arthur L. Norberg and Judy E. O'Neill. Just as funding, in part, explains Hafner and Lyon's focus on BBN, so, too, does funding explain Norberg and O'Neill's organizational focus. The book originated from a Defense Department contract to study the Information Processing Techniques Office (IPTO), with the original idea coming from the office's last director.[14] That support made possible an important set of forty-five interviews, which are extensively used in this book and also in a number

[11] Hafner and Lyon, *Where Wizards*, 79–80.

[12] Martin Campbell-Kelly and William Aspray offer a very good, but brief, version of this analysis in *Computer: A History of the Information Machine* (New York, 1996), 283–94.

[13] Hafner and Lyon, *Where Wizards*, 176.

[14] Norberg and O'Neill, *Transforming Computer Technology*, vii. In 1986, IPTO was restructured and became the Information Science and Technology Office.

of other works on the development of computing, including Hafner and Lyon's book.

Norberg and O'Neill consider not just ARPANET but all ARPA computer funding between 1962 and 1986, including that for time-sharing, graphics, and artificial intelligence as well as networking. Although their book is scholarly in tone and in its extensive research and documentation, they champion their subjects just as Hafner and Lyon do. Throughout, the authors celebrate IPTO's "achievements," "contributions," "accomplishments," and "successes." The book also has its heroes—the bureaucrats who made everything happen. The authors devote one of the book's six chapters to describing and praising IPTO's "lean management structure." The agency's "technical accomplishments," they write, "were shaped as much by IPT office management as they were by researchers' intentions."[15]

By spotlighting ARPA, Norberg and O'Neill emphasize what Hafner and Lyon sometimes obscure—the close connection of all ARPA computer funding to military concerns. Calling their concluding chapter "Serving the Department of Defense and Nation," they celebrate rather than downplay that link. They point out, for example, that ARPA only set up the IPTO in 1962 in response to pressure from the Kennedy administration for improved military command and control systems.[16] Computers, it was widely believed, would make it possible to "control greater amounts of information and to present it in more effective ways to aid decision making." Whereas Hafner and Lyon describe IPTO's first director, J. C. R. Licklider, as pushing it toward basic research, Norberg and O'Neill quote him telling another military official that ARPA should only fund research that offers "a good prospect of solving problems that are of interest to the Department of Defense."[17] Such sentiments were hardly surprising from a man who went to work in the Pentagon the same month as the United States and Soviet Union teetered on the brink of nuclear war over missiles in Cuba.

Norberg and O'Neill also provide a more complete and complex portrait of the Internet's ties to military concerns. They agree with Hafner and Lyon that Taylor's "perceived need to share resources" sparked his initial decision to seek funding for the ARPANET. But they also show that networking experiments grew out of IPTO's fundamental concern with using computers to improve military command and control. Norberg and O'Neill further argue that the military origins of the ARPANET made it successful. While "incentives for networking were lacking in the [computing] community," they "did exist in DOD [Department of Defense], where there was a need to reduce the high cost of software development, improve communications among military units while increasing computer use, [and] further develop command and control systems."[18]

In any case, to focus on the particular "originary" moment of Taylor's search for

[15] Norberg and O'Neill, *Transforming Computer Technology*, 6, 14, 25, 66.

[16] The office was, in fact, initially called the Command and Control division.

[17] Norberg and O'Neill, *Transforming Computer Technology*, 12, 29. Still, there is a difficult problem here of sorting out rhetoric from reality. Abbate maintains that "the agency's disavowal of basic research was more rhetorical than real" and that while "resulting technologies often became part of the military command and control system, the defense rationale may have come after the fact." "From Arpanet to Internet," 77.

[18] Norberg and O'Neill, *Transforming Computer Technology*, 163, 193. They also trace back the networking experiment to Licklider's desire to foster "community" among the researchers funded by

initial funding is to underplay the Internet's multiple origins. By 1972, ARPA had shown the feasibility of packet switching, but it had only created a limited and lightly used network, which also operated in a changed political climate. Starting in the late 1960s, White House and congressional pressure forced ARPA to tie its funding much more closely to military needs.[19] In response to those mandates, ARPA sought to apply directly what it had learned about packet switching to military applications, particularly through packet radio networks and packet satellites. As the additional networks as well as some early commercial networks emerged, Bob Kahn, an engineer who had moved from BBN to ARPA in 1972, and others realized that they had now replicated the problem that had vexed Taylor back in 1966: how do you connect incompatible networks—rather than just computers—to each other? (Kahn, interestingly, had a direct connection to one of the Internet's key alternate origins; it was his cousin Herman Kahn's works on thermonuclear war that had provided the Cold War context for Baran's work on packet switching.)[20]

Out of this military-driven dilemma of "inter-networking" came both the concept and the name of the Internet. Kahn launched the "Internetting Project" to make it possible for "a computer that's on a satellite net and a computer on a radio net and computer on the ARPANET to communicate uniformly with each other without realizing what's going on in between."[21] In collaboration with Vinton Cerf, Kahn developed in 1974 a new and more independent packet-switching protocol—at first called Transmission Control Protocol or TCP and later TCP/IP, with IP standing for "Internet Protocol"—that would serve as a kind of lingua franca for this new Internet. It remains in use today. Not only did military funding and necessity create this standard, but also the adoption of the protocol in 1980 by the Department of Defense for its own operations gave it a crucial boost. Equally important (and surprising given the context) was the Defense Department's public release of TCP/IP—in effect, this normally closed and secretive agency fostered a remarkably open (and hence free) standard of communication.[22]

But the ultimate triumph of TCP/IP was also—as Janet Abbate's informative dissertation makes clear—a matter of international politics and commerce. European telecommunication companies, publicly controlled, pushed an alternative standard (x.25) that would be more compatible with their operations. A key American weapon in the "protocol wars" was Defense Department support, which grew at least in part out of the explicit design of those standards for the military. As a result, TCP/IP boosters could, as Peter Salus notes in *Casting the Net*, persuade

ARPA (154). This point is particularly stressed in Judy O'Neill, "The Role of ARPA in the Development of the ARPANET, 1961–1972," *Annals in the History of Computing* 17 (1995): 76–81.

[19] In 1969, for example, Congress passed a rider—the Mansfield Amendment—to the military reauthorization bill that mandated, "None of the funds authorized to be appropriated by this Act may be used to carry out any research project or study unless such project or study has a direct or apparent relationship to a specific military function or operations." Norberg and O'Neill, *Transforming Computer Technology*, 36.

[20] For Robert Kahn's relationship to Herman, see "An Interview with Robert E. Kahn," conducted by Judy O'Neill, April 24, 1990, Reston, Virginia, Charles Babbage Institute, Center for the History of Information Processing, University of Minnesota, Minneapolis.

[21] Hafner and Lyon, *Where Wizards*, 223.

[22] Hafner and Lyon, *Where Wizards*, 251, 258.

"the military brass that the ARPANET protocols were reliable, available, and survivable."[23] The victory of TCP/IP is not unconnected to why the United States still dominates the Internet.

Norberg and O'Neill provide a thorough institutional study but offer only passing references to the larger political and economic context. They acknowledge that the "political circumstances in the world of the past three decades led the Department of Defense to demand new developments in computing that would help to increase the sophistication and speed of new military systems," but add that "we will not discuss it in this study."[24] This lack of context also contributes to their largely uncritical view of ARPA's military mission. Despite the repeated references to military "benefits" and uses of the computer technology that ARPA funded, Norberg and O'Neill never discuss the actual use of computers on the battlefields of the Vietnam War, which was fought during the heyday of ARPA funding of computer projects.

ALTHOUGH PAUL EDWARDS'S *The Closed World: Computers and the Politics of Discourse in Cold War America* does not focus specifically on the Internet, it still shares many topics and sources with the Norberg and O'Neill and Hafner and Lyon books. Nevertheless, it is also their mirror opposite: whereas Norberg and O'Neill as well as Hafner and Lyon eschew context, Edwards places his story squarely within the narrative of the Cold War and emphasizes the world outside the laboratory; whereas Norberg and O'Neill celebrate (and Hafner and Lyon deny) the marriage of defense and computers, Edwards paints a forbidding portrait of their union; whereas Norberg and O'Neill and Hafner and Lyon provide straightforward (and easy to follow) institutional or biographical histories, Edwards, as a student of Donna Haraway and a graduate of the History of Consciousness program at the University of California, Santa Cruz, draws on and contributes to a large theoretical literature in cultural studies and structures his (sometimes confusing) account more as "collage than linear narrative." Edwards departs most sharply from other works in his abandonment of the trope of "progress" that often marks writing about the history of technology.[25]

The richness and the complexity of Edwards's sometimes brilliant account make

[23] Salus, *Casting the Net,* 126.

[24] Norberg and O'Neill, *Transforming Computer Technology*, 20.

[25] Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, Mass., 1996), xv. John M. Staudenmaier noted the importance for historians of technology of a "master narrative" that offers a "whig reading of Western technological evolution as inevitable and autonomous." He also observed a generational divide in which younger scholars have "argued for a reading of the sometimes technically irrational dimensions of technological decision making as politically or culturally motivated and of the concept of progress in particular as a conceptual tool that helps technical elites to dominate their inferiors." Although Edwards's work is more influenced by Michel Foucault and cultural studies than by the history of technology, his book clearly fits with those emphasizing the "dark side" of technology. Staudenmaier, "Recent Trends in the History of Technology," *AHR* 95 (June 1990): 725. For an essay urging historians of technology to decenter or abandon "progress as a conceptual pivot for research," see Philip Scranton, "Determinism and Indeterminancy in the History of Technology," in Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, Mass., 1994), 148.

it difficult to summarize briefly.[26] Edwards contends that the digital computer is both cause and effect of what he calls the Cold War's "closed-world discourse," which he defines as "the language, technologies, and practices that together supported the visions of centrally controlled, automated global power at the heart of American Cold War politics." "Computers," he writes, "created the technological possibility of the Cold War and shaped its political atmosphere." And, in turn, "the Cold War shaped computer technology." Cold War politics "became embedded in the machines," including their "technical design," and the "machines helped make possible its politics." In this way, Edwards goes beyond historians who argue for the "social construction" of technology and focus on how different social groups shape the development of technology. He emphasizes instead what he calls the "*technological construction of social worlds*." Computers in this analysis, heavily influenced by the work of Michel Foucault, become themselves a source of power and knowledge—or in Edwards's words, "a crucial infrastructural technology—a crucial Foucaultian support—for the Cold War closed-world discourse."[27]

That the Cold War, if not Cold War discourse, fostered the development of digital computers is relatively easy to show.[28] In 1950, for example, the federal government—overwhelmingly, its military agencies—provided 75 to 80 percent of computer development funds. Even when companies began funding their own research and development, they did so with the knowledge of a guaranteed military market. Such massive government support enabled American computer research to destroy foreign (mostly British) competition; the American hegemony in computer markets—routinely attributed to American free markets—rests on a solid base of government-subsidized military funding. "The computerization of society," writer Frank Rose aptly observes, "has essentially been a side effect of the computerization of war."[29]

Such facts are relatively well known (although sometimes ignored by ideologues who depict the computer industry as the exemplar of laissez faire), but Edwards wants to make a deeper argument about the significance of military involvement in computer development. He rejects the idea that "military support for computer research was . . . benign or disinterested"—a view he attributes to historians who take "at face value the public postures of funding agencies and the reports of

[26] A considerable portion of Edwards's book deals with developments in artificial intelligence and what he calls the "cyborg discourse," which I have not discussed here.

[27] Edwards, *Closed World*, ix, 7, 34, 41. For the social constructivist approach, see, for example, Wiebe E. Bijker, *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change* (Cambridge, Mass., 1995). For a sharp critique, see Langdon Winner, "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology and Human Values* 18 (Summer 1993): 362–78. Abbate described social constructionism and systems theory as the key influences on her work. "From Arpanet to Internet," 7.

[28] For a general discussion of the centrality of military funding to postwar American science and technology, see Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York, 1993). See also such works as Everett Mendelsohn, Merritt Roe Smith, and Peter Weingart, eds., *Science, Technology, and the Military*, 2 vols. (Dordrecht, 1988); David F. Noble, *Forces of Production: A Social History of Automation* (New York, 1984); Merritt Roe Smith, ed., *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge, Mass., 1985); Ann Markusen, *et al.*, *The Rise of the Gunbelt: The Military Remapping of Industrial America* (New York, 1991); and the issue of *Osiris* 7 (1992) on "Science after '40," edited by Arnold Thackray.

[29] Quoted in Edwards, *Closed World*, 65.

project leaders." (He could be talking directly about the Hafner and Lyon and Norberg and O'Neill books, but their work appeared either after or at the same time as his book.[30]) Rather, he argues, "practical military objectives guided technological development down particular channels, increased its speed, and helped shape the structure of the emerging computer industry." For example, he maintains that the shift from analog to digital computing was not the result of the innate technological superiority of the latter but of the digital approach's better correspondence with and support for the vision of centralized command and control of the closed-world discourse.[31] Unfortunately, Edwards never makes clear precisely how computing would look different today without defense funding under the shadow of the Cold War. Would we have analog computers on our desks—or none at all?

Indeed, Edwards is more interested in showing that computer technology helped create and develop the discourse of centralized command and control than in exploring how this vision actually shaped computer design. Computers, he writes, "helped create and sustain this discourse" by allowing the "practical construction of central real-time military control systems on a gigantic scale" and facilitating "the metaphorical understanding of world politics as a sort of a system subject to technological management."[32]

Much of this sounds and is rather abstract, but Edwards leavens the book's relentless abstractions with a series of rich case studies and anecdotes. We learn, for example, about U.S. Air Force Operation Igloo White. Run from the Infiltration Surveillance Center in Thailand (the largest building in Southeast Asia) and costing nearly $1 billion per year between 1967 and 1972, Igloo White sought to monitor all activity across the Ho Chi Minh Trail in southern Laos, including truck noises, body heat, and the scent of human urine. When the sensors ("shaped like twigs, jungle plants, and animal droppings") picked up signals, they appeared magically on the display terminals as "a moving white 'worm' superimposed on a map grid." Then the computers would project the "worm's" movements and radio the coordinates to Phantom F-4 jets, whose computers would guide them to the precise map grid square; the computers back in Thailand controlled the release of the bombs. "The pilot," observes Edwards, "might do no more than sit and watch as the invisible jungle below suddenly exploded into flames." It was the perfect fantasy of the closed world of computerized and centralized command and control. In the apt words of one technician: "We wired the Ho Chi Minh Trail like a drugstore pinball machine, and we plug it in every night." But the "pinballs" were smarter than the players. The Vietcong fooled the sensors with taped truck noises and bags of urine, which duly provoked massive air strikes on empty jungle corridors. These air strikes were then

[30] Edwards, *Closed World*, 44. He did, however, read the unpublished 1992 report that was the basis of the Norberg and O'Neill book.

[31] For another account that persuasively undercuts the inevitability or "obviousness" of the triumph of digital over analog computing, see Larry Owens, "Where Are We Going, Phil Morse? Changing Agendas and the Rhetoric of Obviousness in the Transformation of Computing at MIT, 1939–1957," *IEEE Annals of the History of Computing* 18, no. 4 (1996): 34–41. Owens offers a number of non-technical reasons for the triumph of the digital computing, including "Cold War worries about unrest, uncertainty, and unpredictability [that] fed a countervailing emphasis on management and control" (p. 38).

[32] Edwards, *Closed World*, 7.

claimed as quantitative (and quantifiable) successes. A 1971 Senate report found that "truck kills claimed by the Air Force [in Igloo White] last year greatly exceeds the number of trucks believed by the Embassy to be in all of North Vietnam." Even if the exaggerated claims had been true, they could only have been scored as successes in a crazy world in which it would have cost $100,000 to destroy trucks and supplies worth a few thousand dollars.[33]

Igloo White, as Edwards shows, typified computerized Cold War military operations. He devotes a chapter to the Semi-Automatic Ground Environment (SAGE) computerized air defense system, which cost billions of dollars and was obsolete by the time it was fully operational in 1961. But in the irrational closed world of the Cold War, SAGE actually "worked," as Edwards argues. Computer scientists got to pursue their research; IBM Corporation built its dominance of the computer industry with the help of the massive SAGE contract. And on an ideological level, SAGE worked by "creating an impression of active defense that assuaged some of the helplessness of nuclear fear" and fostering the myth of centralized control and total defense.

Although Edwards offers little directly on the ARPANET, it is difficult to read his book and then share Hafner and Lyon's or Norberg and O'Neill's view of the connection between the military and the rise of the Internet as accidental or benign. One of the sharpest differences between Edwards's account and the others is in the depiction of J. C. R. Licklider, who twice directed IPTO and whose famous 1960 paper on "man-machine symbiosis" helped shift computing from computation to communication. For both Hafner and Lyon and Norberg and O'Neill, Licklider is an almost sainted figure. "Everybody adored Licklider," Hafner and Lyon write. "His restless, versatile genius gave rise through the years to an eclectic cult of admirers." His "worldview," they write, "pivoted" on the idea "that technological progress would save humanity."[34]

In these other accounts, particularly Hafner and Lyon's, Licklider's concern with "man-machine" interaction appears as largely an intellectual problem. But Edwards maintains that it grew directly out of his World War II work in Harvard's Psycho-Acoustic Lab, which sought to reduce "noise" in battlefield communications systems. Such military concerns continued to inform Licklider's work after the war. In his 1960 paper, for example, he explains the problem with batch processing (as opposed to real-time interactive computing) by writing: "Imagine trying . . . to direct a battle with the aid of a computer on such a schedule as this." Edwards thus depicts Licklider as tightly wedded to military goals, describing him as "deeply desir[ing] to contribute to new military technologies from his areas of expertise." Writing in 1978, Licklider expressed some frustration that the World-Wide Military Command and Control System's computers were not yet "interconnected by an electronic network" and used an operating system designed for "batch processing." He argued that "military command and control and military communications are prime network applications" and observed that "both interactive computing and networking had their origins in the SAGE system."[35] But regardless of Licklider's

[33] Edwards, *Closed World*, 3–4.
[34] Hafner and Lyon, *Where Wizards*, 29, 34. They dedicate their book to Licklider's memory.
[35] J. C. R. Licklider, "Man-Computer Symbiosis," *IRE Transactions on Human Factors in Electronics*,

own views, the Defense Department would never have committed funds to projects like ARPANET without the belief that they would ultimately serve specific military objectives and larger Cold War goals.

Thus it becomes clear that computer systems were invented for the Cold War, which provided the justification for massive government spending, and were pushed in particular technological directions. But these same computer systems, in turn, helped to support the discourse of the Cold War; they sustained the fantasy of a closed world that was subject to technological control. Even before ARPANET, the first real computer network was developed by the SAGE project because "the massive integration of a centralized, continental defense control system" required "long-distance communication over telephone lines."[36]

If the Internet, like networking and computing, in general, was a "side effect of the computerization of war," did it also support that militarized and closed vision of the world? On the one hand, the notion of a network of interconnected computers—especially one that could survive nuclear attack—fostered the fantasy of centralized command and control that Edwards sees as crucial to closed-world discourse. Moreover, at least in Defense Department hands, the ARPANET was quite literally a "closed world" to which only a select number of ARPA-funded sites had access. But, on the other hand, Baran's distributed network—perhaps precisely because it responded to a *post*-nuclear war scenario—could also have nurtured a highly decentralized view of the world. Norberg and O'Neill report, for example, that Defense Department officials initially viewed the new network with suspicion because it would "make it easier for subordinates to send messages without the approval of commanding officers, possibly circumventing the military's chain of command."[37]

And in the 1960s, there were plenty of reasons to worry about subversion of the chain of command and of military thinking, in general—a fact that Edwards's closed-world analysis seems to ignore.[38] He provides an often perceptive analysis of some of the key Cold War era films, for example. But he does not give enough weight to the way that *Dr. Strangelove* (1964) both popularized the closed-world discourse but also undercut it by showing the idea of controlling the nuclear world to be an absurd fantasy. Some leading scientists also came to have doubts. In December 1968, fifty senior faculty members at MIT—the center for the most important developments in computing as well as the country's biggest academic defense contractor—circulated a statement that started: "Misuse of scientific and

vol. HFE-1 (March 1960): 5; Edwards, *Closed World*, 272; J. C. R. Licklider and Albert Vezza, "Applications of Information Networks," *Proceedings of the IEEE* [Institute of Electrical and Electronics Engineers] 66 (November 1978): 1335. Licklider later told an interviewer that he had "this positive feeling toward the military. It wasn't just to fund our stuff but they really needed it and they were good guys." Edwards, *Closed World*, 267.

36 Edwards, *Closed World*, 101.

37 Norberg and O'Neill, *Transforming Computer Technology*, 270.

38 Although Edwards devotes little attention to counter-discourses, he does note the "survival" in the current moment of "vestiges" of a "green-world discourse," which he locates in "animistic religions, feminist witchcraft, certain Green political parties, and the deep ecology movement," but he says these "lie at the farthest margins of politics, society, and culture." He argues (and it is an argument that I have trouble following) that "the only possibility for genuine self-determination, is the political subject position of the cyborg." Edwards, *Closed World*, 350.

technical knowledge presents a major threat to the existence of mankind. Through its actions in Vietnam our government has shaken our confidence in its ability to make wise and humane decisions." That declaration led directly to the founding of the Union of Concerned Scientists early the next year; the group particularly challenged the conventional wisdom on nuclear weapons and fostered debate over military funding of academic research.[39] At least some scientists were beginning to question closed-world visions, and, indirectly, Edwards's own work emerges out of that critical tradition.[40]

Those creating the ARPANET could hardly have been unaware of these protests. Just six months before the network's first successful connection in October 1969 between UCLA and the Stanford Research Institute (SRI), massive student protests focused on SRI, calling for an end to all classified, chemical warfare, and counterinsurgency research. On April 18, 1969, 8,000 students and faculty at Stanford voted to commend the protesters for "helping focus attention of the campus upon the nature of research being conducted at the University and SRI."[41] Antiwar protesters across the country repeatedly targeted closed or classified research.

In addition to those who frontally assaulted the closed-world vision of the defense establishment, there were those who took a less direct but still subversive approach. ARPA money supported the "hackers" at MIT's Artificial Intelligence Lab, but some of their goals—the free sharing of information, for example—led to direct clashes. Richard Stallman, a systems programmer at the lab, carried on a guerrilla war against the use of passwords on the system. The lack of security encouraged by Stallman and others caused nervousness at the Defense Department, which threatened to cut the computer off the ARPANET, since anyone could walk into the lab and connect to the rest of the network.[42]

An even more important question about the connection between closed-world discourse and the Internet is how the new global network operated in practice. Edwards shows that military systems like Igloo White and SAGE did not work as planned. What were actual workings of the ARPANET and Internet? To the biographical, bureaucratic, and ideological histories of the Internet, we need to add a social and cultural history.

[39] Statement reproduced in Union of Concerned Scientists, *1993 Annual Report* (Cambridge, Mass., 1994), inside front cover. See also undated flier "The Beginnings" from Union of Concerned Scientists, Cambridge, Mass.; and Leslie, *Cold War and American Science*, 233–41.

[40] In the aftermath of demonstrations against military research at the Stanford Research Institute, one group of graduate students, under faculty sponsorship, organized a course on sponsored research at Stanford, which sought to understand "how a generation of close interaction with the Department of Defense has affected Stanford as an academic institution." Quoted in Leslie, *Cold War and American Science*, 248. The group published two volumes on Defense Department research at Stanford. More generally (and from a critical vantage), Brook Hindle argues that "darkside" views of science and technology emerged out of radical protests of the 1960s. Hindle, "Historians of Technology and the Context of History," in Cutcliffe and Post, *In Context*, 235–40.

[41] Leslie, *Cold War and American Science*, 245.

[42] Steven Levy, *Hackers: Heroes of the Computer Revolution* (1984; rpt. edn., New York, 1994), 416–18.

MICHAEL AND RONDA HAUBEN'S *Netizens: On the History and Impact of Usenet and the Internet* offers a strikingly different historical narrative of the Internet—one that insists that the real story is not of the "wizards" who built the Internet but of the "Netizens" who figured out what it was "really" for and popularized it. In their populist account, ordinary users who realized that it offered a marvelous medium for democratic and interactive communication created the soul of the new network from the bottom up. And while the book is sometimes repetitive and poorly written, it offers an interpretive perspective that should be central to any future Net history.[43]

The Haubens see the bottom-up origins of the Internet in "Usenet," the international computer newsgroup network that has more recently been overshadowed by the World Wide Web but still has a substantial presence on the Internet—more than 30,000 different newsgroups covering everything from alien visitations (alt.alien.research) to Zoroastrianism (alt.religion.zoroastrianism). In 1979, two Duke University graduate students, Tom Truscott and Jim Ellis, working with other students at nearby schools, developed some simple programs through which computers using the popular Unix operating system could call each other and exchange files. In effect, the system made possible an online newsletter that would be continuously updated. Those with access to any of the connected computers could read the news postings and add their own comments with the knowledge that they would be quickly read by everyone else; the same program allowed e-mail to be sent between the Unix computers connected by phone modems.

The graduate students consciously saw themselves as offering a networking alternative to the ARPANET, then still limited for reasons of cost and security to Defense Department–funded sites.[44] Several months later, they described Usenet as trying to "give every Unix system the opportunity to join and benefit from a computer network (a poor man's ARPANET, if you will)." Another of the graduate students, Stephen Daniel, later recalled that they had "little idea of what was really going on on the ARPANET, but we knew we were excluded."[45] The students' insurgent computer network grew with startling speed: from the initial three sites to 150 two years later, then jumping to 5,000 by 1987. In 1988, Usenet connected 11,000 sites, and participants posted about 1,800 different articles each day. Usenet grew along with the runaway popularity of Unix, which became the standard operating system for the 1980s. A crucial breakthrough had come in 1981 after Usenet gained a tenuous one-way connection from the ARPANET (linked between different computers at the University of California, Berkeley). When graduate student Mark Holton established this gateway, he pierced what some disgruntled Usenet participants described as the "iron curtain" surrounding ARPANET.[46] Barriers fell further two years later when the Defense Department segmented off

[43] David Hudson offers a similar "bottom up" perspective on the Net's history in *Rewired*, 13–35.

[44] Campbell-Kelly and Aspray, *Computer*, 293.

[45] Michael Hauben and Ronda Hauben, *Netizens: On the History and Impact of Usenet and the Internet* (Los Alamitos, Calif., 1997), 41.

[46] Hauben and Hauben, *Netizens*, 172; Campbell-Kelly and Aspray, *Computer*, 221. Unix was initially developed at AT&T's Bell Labs in the late 1960s. Although the system was a commercial development, AT&T was prevented by a 1956 consent decree from profiting from sources other than the phone business. As a result, they made Unix widely and cheaply available, and by the 1970s, it became a widely used standard, particularly in academic computing, where a university license cost only $150.

its military communications into MILNET, which made it less nervous about what traveled over the ARPANET.

The runaway growth of Usenet as a forum for conversation and communication was paralleled by the earlier discovery of e-mail as the most popular use for ARPANET. In 1972, BBN engineer Ray Tomlinson, working on his own, developed a program for sending mail messages across the ARPANET. By the following year, three-quarters of network traffic was devoted to e-mail. Almost overnight, the empty highway found its cars; to this day, e-mail remains the most popular use of the Internet.[47] As with Usenet, e-mail had come from "below," from computer users, who wanted to communicate with other computer users, rather than ARPA directives from above. And as with Usenet, the technology had emerged from someone "hacking" around, rather than carrying out an official plan.

Much of the Haubens's book is devoted to a somewhat hyperbolic celebration of Usenet and other computer networks as a democratic and "uncensored forum for debate" that is the "successor to other people's presses, such as broadsides at the time of the American Revolution and the penny presses in England." They argue that the Internet has created a new kind of citizen, the "Netizens," who they define as "people who decide to devote time and effort into making the Net, this new part of the world, a better place"—"a regenerative and vibrant community and resource."[48] The Haubens see the democratic nature of the network growing out of its grass-roots source in the people who created Usenet.

In addition to emphasizing this later moment of creation for the Internet and locating its paternity in the person of some Duke graduate students, the Haubens also give a more democratic and grass-roots spin to the earlier history of ARPANET. In particular, they stress a moment in the development of ARPANET that others have described but not necessarily in the same populist tones. This came early in 1969 when BBN convened a "Network Working Group" to devise the protocols for the new network. Steve Crocker, a bearded young UCLA graduate student, agreed to write up notes from the meetings. Crocker framed his notes to emphasize that "anyone could say anything and that nothing was official." He labeled them "Request for Comments" and this ongoing series of "RFCs" (distributed ultimately through the medium of the network) became the way that Internet standards have evolved to this day.[49]

The Haubens, not surprisingly, celebrate the philosophy behind the RFCs as representing "unprecedented openness" that fostered the "amazing and democratic" achievement of the Net and its "cooperative culture." They also remind us that the decision to evolve technical standards in such an open-handed way came at a particular moment in time—the 1960s. "The open environment needed to develop new technologies," they write, "is consistent with the cry for more democracy that students and others raised throughout the world during the 1960s." Not surprisingly, the builders of the APRANET were well aware of this context. Writing in

[47] Hafner and Lyon, *Where Wizards*, 187–218.

[48] Hauben and Hauben, *Netizens*, 48–49, x. The second quote comes from a preface signed separately by Michael Hauben. The other chapters appear to have been individually written by Rhoda and Michael (who are mother and son), and Michael's chapters tend to take a more aggressively populist stance.

[49] Hauben and Hauben, *Netizens*, 102–05.

1987 on "The Origins of RFCs," Crocker recalls that "the procurement of the ARPANET was initiated in the summer of 1968—Remember Vietnam, flower children, etc.?"[50] By placing the rise of the Internet within the 1960s-as-counterculture and the 1960s of the antiwar movement, Crocker and the Haubens suggest an alternative contextual frame to that emphasized by Edwards, who puts the rise of digital computing (and implicitly the Internet) solely within the Establishment 1960s of the Vietnam War and the Cold War.

Both contexts are, of course, important and suggest how we might revise Edwards's analysis to see the Internet as shaped both by the "closed world" discourse of the Cold War and by the "open world" discourse of the antiwar movement and the counterculture. Such an analysis would also incorporate the entertaining and revealing story Steve Levy tells in *Hackers: Heroes of the Computer Revolution*. Levy discerns among the hackers of the 1960s and 1970s (who he defines as "those computer programmers and designers who regard computing as the most important thing in the world") a "philosophy of sharing, openness, decentralization, and getting your hands on machines at any cost—to improve the machines, and to improve the world." Although this "hacker ethic" was not simply the technological side of the counterculture and the antiwar movement, it drew from some of the same sources. "All over the Bay Area," Levy writes of the early 1970s, "the engineers and programmers who loved computers and had become politicized during the anti-war movement were thinking of combining the two activities." In 1972, for example, Bob Albrecht launched a tabloid called *People's Computer Company* (inspired by Janis Joplin's group, Big Brother and the Holding Company), which proclaimed on the cover of its first issue: "COMPUTERS ARE MOSTLY USED AGAINST PEOPLE INSTEAD OF FOR PEOPLE. USED TO CONTROL PEOPLE INSTEAD OF TO FREE THEM. TIME TO CHANGE ALL THAT—WE NEED A . . . PEOPLE'S COMPUTER COMPANY." Among the frequent visitors to the paper's potluck dinners was Ted Nelson, the author of the self-published manifesto of counterculture computing: *Computer Lib*.[51]

Berkeley's Community Memory project similarly merged the impulses of the radical 1960s with the hacker ethic by setting up a time-shared mainframe computer on the second floor of a record store and opening it to free, public use as a kind of combined electronic version of a public library, coffeehouse, urban park, game arcade, and post office. Community Memory embodied, as Levy says, the effort to take "the Hacker Ethic to the streets" and to allow people to use computer technology "as guerrilla warfare for people *against* bureaucracies." Not coincidentally, some aspects of Community Memory—the decentralization and the free sharing of information—sound like the Internet. And Levy argues that the ARPANET "was very much influenced by the Hacker Ethic, in that among its

[50] Stephen D. Crocker, "The Origins of RFCs," in J. Reynolds and J. Postel, *RFC 1000: The Request for Comments Reference Guide*, August 1987, available on the World Wide Web at http://info.internet.isi.edu:80/in-notes/rfc/files/rfc1000.txt; Hauben and Hauben, *Netizens*, 103, 106–07. The most detailed discussion of the RFCs can be found in Salus's more technically oriented history: *Casting the Net*. Many of the RFCs can be found on the web at pages maintained by the University of Southern California's Information Sciences Institute: www.isi.edu/rfc-editor.org/rfc.html.

[51] Levy, *Hackers*, 7, 168, 172. On Nelson, see Gary Wolf, "The Curse of Xanadu," *Wired* 3 (June 1995): 137 and following.

values was the belief that systems should be decentralized, encourage exploration, and urge a free flow of information."[52]

Among the founders of Community Memory was Lee Felsenstein, a red diaper baby (son of a district organizer for the Philadelphia Communist Party) who had worked as an audio technician for the Free Speech Movement and spent the 1960s moving between seemingly contradictory existences as engineer and political activist. He embodied the two key groups that Martin Campbell-Kelly and William Aspray identify as the vanguard for the personal computer revolution of the early 1970s—first, computer hobbyists who emerged out of the world of radio and electronics aficionados and loved the idea of building their own equipment and, second, computer liberationists who emerged out of the New Left and the counterculture and loved the idea of bringing computers to the people. In the 1970s, Felsenstein became the moderator of the famous "Homebrew Computer Club," where computer hobbyists and computer liberationists came together to create the first PCs. (When Felsenstein made a big score himself by designing the Osborne personal computer, he plowed the money into Community Memory.) Activist and counterculturist hackers like Felsenstein, in effect, tried to turn the closed-world discourse on its head and make the personal computer and community networks into "supports" (to use Edwards's term) for a discourse of freedom, decentralization, democracy, and liberation.[53]

Some of the computer developments of the late 1960s and the 1970s, while less directly shaped by radical politics or the counterculture, still bear the imprint of the period. Ken Thompson and Dennis M. Ritchie, the bearded and longhaired Bell Labs' programmers who, in 1969, developed Unix, the operating system behind Usenet, later described themselves as seeking "a system around which a fellowship could form." As Campbell-Kelly and Aspray point out, "Unix was well placed to take advantage of a mood swing in computer usage in the early 1970s caused by a growing exasperation with large, centralized mainframe computers."[54] Protests in the 1960s had featured students wearing punch cards around their necks with the slogan "Do Not Fold, Bend, Mutilate or Spindle," but the hostility to the large mainframe computers and centralized batch processing extended beyond radical students to computer scientists and computer users who increasingly favored decentralized smaller computers, often running Unix.[55] Not coincidentally, Unix-style operating systems, not dependent on proprietary hardware and software standards, have become known among computer scientists as "open systems."

Still, it would be a mistake to collapse the story of computers and the Internet into the story of the radical 1960s, as the Haubens do sometimes. When MIT went on "strike" on March 4, 1969, most students and faculty spent the day, as usual, in

[52] Levy, *Hackers*, 272, 156, 143. In a delightful irony that must have been evident to the people behind Community Memory, the computer used was an XDS-940, but it was also known by its original initials, which were very familiar to 1960s activists—SDS. (The change reflected the takeover of Scientific Data Systems by Xerox Corporation.) The online "Community Memory Discussion List on the History of Cyberspace" is named after the Berkeley project. See http://memex.org/community-memory.html.

[53] Levy, *Hackers*, 157–68, 181–87, 196–97, 205–06, 214–17, 237–42, 272–77.

[54] Campbell-Kelly and Aspray, *Computer*, 220–21.

[55] For the origins of the phrase, see "Free Speech Movement: Do Not Fold, Bend, Mutilate or Spindle," anonymous statement from *FSM Newsletter*, reproduced by *Sixties Project* web site at http://lists.village.virginia.edu/sixties/HTML_docs/Resources/Primary/Manifestos/FSM_fold_bend.html.

their labs and classes.[56] Moreover, many radicals wanted to smash technology rather than liberate it. In 1962, the Port Huron statement had lyrically celebrated the potential of science to "constructively transform the conditions of life throughout the United States and the world," but in 1964 Mario Savio, the son of a machinist, had spoken eloquently of the need to "put your bodies upon the gears and upon the wheels" to stop "the machine." And by the late 1960s, many counterculture adherents headed for rural communes.[57] To make the case for the impact of 1960s radicalism on the rise of networking requires a more precise social and political history. We need to know more about the graduate students who crafted the first "Requests for Comments." Some of them may have had beards, but most were also willing to take Defense Department funding, which their more radical counterparts would have eschewed. Such a wider social history would also probably help us see that the Internet and Usenet originated in a "community" but also a very specific kind of community—young graduate students and faculty in Computer Science and related fields. When those young engineers and scientists turned ARPANET into a mail system rather than a medium for sharing computer resources and formulated Usenet, they were participating in a "quest for community"—but the most important component of that community was technical knowledge rather than sixties-style politics and culture.

To be sure, there were signs of the 1960s on the early networks: drug deals and antiwar messages, for example, flowed through the ARPANET.[58] But the largest amount of traffic was initially about technical matters; the very first e-mail discussion group (MsgGroup), launched in June 1975, was about e-mail itself—participants argued heatedly about such fascinating topics as the proper format for e-mail headers. The first invitation to participate in Usenet promised discussions of "bug fixes, trouble reports, and general cries for help."[59]

As late as 1982, most ARPANET and Usenet discussion groups still focused on technical matters. Most other group discourse reflected the leisure pursuits of young male engineers and computer scientists—science fiction, football, ham radios, cars, chess, and bridge.[60] Only a few groups considered more broadly political topics like alternate energy production. While the Haubens romanticize

[56] Leslie, *Cold War and American Science*, 233–34.

[57] The Port Huron statement is available at http://lists.village.virginia.edu/sixties/HTML_docs/Resources/Primary/Manifestos/SDS_Port_Huron.html. (The most remarkable statement from a subsequent perpective is its warm embrace of nuclear energy.) For Savio's famous statement, see W. J. Rorabaugh, *Berkeley at War: The 1960s* (New York, 1989), 31. The alternative neo-Luddite strain in New Left and counterculture thought remains potent today. See, for example, Kirkpartrick Sale, *Rebels against the Future: The Luddites and Their War on the Industrial Revolution; Lessons for the Computer Age* (Reading, Mass., 1995).

[58] Severo Ornstein, one of the key BBN engineers, once wore an antiwar button to a briefing on ARPANET with Pentagon officials. Hafner and Lyon, *Where Wizards*, 113. Ornstein went on to become the chair of Computer Professionals for Social Responsibility. See Severo M. Ornstein, "Computers in Battle: A Human Overview," in David Bellin and Gary Chapman, eds., *Computers in Battle—Will They Work?* (Boston, 1987), 1–43.

[59] Hauben and Hauben, *Netizens*, 40.

[60] These works devote surprisingly little attention to analyzing the obvious role of gendered concepts and practices in a development in which the key figures were almost entirely men. Edwards does offer an interesting analysis of the gendered language of "hard" and "soft" sciences and approaches. Edwards, *Closed World*, 167–73. See also his essay, "The Army and the Microworld: Computers and the Militarized Politics of Gender," *Signs* 16, no. 1 (1990): 102–27.

the early days of Usenet and ARPANET as the nesting ground for a broad democratic community, it was the creation of a rather more specific form of community. The "MsgGroup," explained a Carnegie Mellon graduate student in 1977, "is the closest that we have to a nationwide computer science community forum." And for computer science students who were at schools not privileged to have an APRANET connection, Usenet was, as one of them explained, "our way of joining the Computer Science community and we made a deliberate attempt to extend it to other not-well-endowed members of the community."[61]

Indeed, the rapid growth of Computer Science as an academic discipline in the 1960s and 1970s paralleled and fostered the rapid growth of the Net. In 1962, Purdue and Stanford universities set up the country's first two computer science departments; by 1979, there were about 120. That only fifteen of these universities had ARPANET connections fostered the sense of exclusion that led Truscott and Ellis and other graduate students to create Usenet. Back in 1974, the National Science Foundation had proposed a network for academic computer scientists that would "offer advanced communication, collaboration, and the sharing of resources among geographically separated or isolated researchers."[62] In the early 1980s, that network emerged as CSNET, and, by the mid-1980s, it connected almost all U.S. universities' computer science departments. CSNET had connections into APRANET, and it became one of several different networks (for example, BITNET) that would later be combined into the Internet.

While this quest for professional (and male) community may have lacked the political edge of 1960s radicalism, it drew on some of the remnants of a sixties-style ethos, which was still very much alive at universities in the 1970s. Even something as seemingly self-evident as e-mail was propelled by winds of change blowing from the 1960s. As Ian Hardy points out in his study of the emergence of e-mail, the medium's "disdain for false formality, its distrust of traditional hierarchy, its time-selfishness, speed, and certainly its ironic juxtaposition of impersonality and emotional directness" represented a "new culture of interaction" that might not have been so readily possible without what Kenneth Cmiel calls the "informalization" of culture that the 1960s brought.[63] In general, then, many of the "open" qualities of the Internet can be seen as rooted, at least in part, in impulses that came from the 1960s—the open process of creating standards through RFCs drew on challenges to hierarchy and commitments to candor; the rise of e-mail and newsgroups was influenced by a powerful quest for community as well as a growing informality in communication (both in habits of speech and in the rise of alternative newspapers); the interest in decentralized networks gained support from a distrust of large centralized structures, including centralized batch-processing computing

[61] Hafner and Lyon, *Where Wizards*, 210; Hauben and Hauben, *Netizens*, 41. See also Campbell-Kelly and Aspray, *Computer*, 292.

[62] Hafner and Lyon, *Where Wizards*, 240. On NSF and the Internet, see David Roessner, *et al.*, "The Role of NSF's Support of Engineering in Enabling Technological Innovation," First Year Final Report, January 1997, prepared for the National Science Foundation, available on the World Wide Web at www.sri.com/policy/stp/techin/.

[63] Ian Hardy, "The Evolution of ARPANET Email," unpublished Senior Thesis, University of California, Berkeley, 1996, available at http://ifla.inist.fr/documents/internet/hari1.txt. On the "informalization" of American society in the 1960s, see Kenneth Cmiel, "The Politics of Civility," in David Farber, ed., *The Sixties: From Memory to History* (Chapel Hill, N.C., 1994), 263–90.

and the desire to share information freely; and the rise of alternative networks like Usenet was supported by an effort to break down modes of exclusion. Ironically, while the Department of Defense had very different goals in mind—and often tried to implement them by, for example, restricting access to the APRANET or to what it could be used for—its willingness to embrace the open technical standards embodied in TCP/IP inadvertently sparked the creation of a remarkably open system.

The apparent failure of the Cold War discourse to police its own boundaries suggests that what we think of as "sixties" hostility to conformity and hierarchy had much broader and deeper sources than just the counterculture, as Thomas Frank shows in his recent book on business and the counterculture, *The Conquest of Cool*. "The meaning of 'the sixties,'" he writes, "cannot be considered apart from the enthusiasm of ordinary, suburban Americans for cultural revolution."[64] A broader picture of the 1960s would, then, include computer science graduate students rejecting proprietary, hierarchically organized, batch-processing computer systems running on IBM mainframes as well as longhaired hippies smoking dope at Woodstock. Or maybe the closed world of the military and the open world of the hippies were not as separate as we sometimes think—at the heart of the military-industrial complex we might find beatnik Maynard G. Krebs with a math degree.[65]

In different ways, both Levy and the Haubens help us to see that the more profound challenge to this "open" vision of the Internet that was rooted (at least in part) in the 1960s came not from its heritage in the Defense Department but rather from an alternative, closed system—corporate capitalism. In 1975, after the first personal computer, the Altair, appeared on the cover of *Popular Electronics*, two teenagers, working from the plans, wrote a BASIC program for the new machine. But even before MITS, the Altair's manufacturer, officially released the program, bootleg copies circulated rapidly among computer enthusiasts imbued with the hacker ethic that "information wants to be free."[66] One of the teenagers, whose name was Bill Gates (the other was Paul Allen), wrote an angry "Open Letter to Hobbyists" arguing that people who wrote software ought to get paid. Gates's letter augured a new world in which, Levy writes, "money was the means by which computer power was beginning to spread."[67] Information could not remain free when people were paying large sums in cash.

For the Net, the transition from public or open to private and proprietary started around the same time and also quickly got entangled in questions of "ownership." In 1972, ARPA announced that it wanted to sell the network, but the major

[64] Thomas Frank, *The Conquest of Cool: Business Culture, Counterculture, and the Rise of Hip Consumerism* (Chicago, 1997), 13.

[65] For a detailed discussion of the links between the drug culture and the contemporary computer industry, see Douglas Rushkoff, *Cyberia: Life in the Trenches of Hyperspace* (San Francisco, 1994). According to Rushkoff, programmers regularly circulate lists of which companies are "friendly" to drug users and don't do drug testing (p. 30).

[66] This widely repeated phrase was first used (in print) by Stewart Brand, *The Media Lab: Inventing the Future at M.I.T.* (New York, 1987), 202. Less widely used is his corollary that "information also wants to be expensive"—"free" because "it has become so cheap to distribute, copy, and recombine" and "expensive" because "it can be immeasurably valuable to the recipient."

[67] Levy, *Hackers*, 229, 268.

telecommunications corporations (including AT&T) showed little interest. Others more closely associated with the development of the new networks, however, saw money to be made. BBN, for example, set up its own subsidiary Telenet to provide commercial services and brought in none other than ARPA official Larry Roberts as the president of the new business. A dispute quickly ensued over whether BBN had to share the "source code" for the Interface Message Processors with their emerging competitors. In this case, government muscle forced BBN to make the code openly available, but it heralded a new era in which corporations would make huge sums off computer software initially developed at government expense.[68]

Telenet and some competitors drew directly on the open technologies developed by ARPANET. But some commercial firms took an opposite strategy. Large computer firms such as IBM and Digital Equipment developed proprietary networks—SNA and DECNET, for example—with the goal of keeping customers tied to their own hardware and software.[69] But ironically, the Defense Department's embrace of the "open standards" of the Internet doomed these efforts to failure. That failure did not, however, keep the Net from moving from a subsidized public good to an arena for profit making. In the 1980s, the National Science Foundation, which had taken control of the Internet from ARPA, moved to privatize it. Populists like the Haubens have bemoaned the transformation from public to private control and ownership, yet the change evoked remarkably little protest. In the 1980s, when most forms of publicly owned goods and services—from public schools and public housing to public parks—were in decline and an ideology of privatization and deregulation was in ascendance, it seemed like conventional wisdom to turn this public utility over to private ownership.

By the 1980s (and especially by the 1990s), moreover, many of the people who had celebrated the freedom and openness of networks and personal computers had also undergone a transformation that made them inclined to accept this privatization. The affection of many "Netizens" for free speech and freedom from control had also come to embrace a love for free markets. The liberationism of the many early computer and network enthusiasts had been transformed into libertarianism. "Technolibertarianism" became one of the central ideologies of the Internet. Many computer liberationists of the 1960s and 1970s now find themselves aligned with conservative free market prophets such as George Gilder and Alvin Toffler.[70] This may be less contradictory than it seems on the surface. As Mark Lilla has recently argued, "the cultural and Reagan revolutions took place within a single generation, and have proved to be complementary, not contradictory events." Americans, he writes, "see no contradiction in holding down day jobs in the unfettered global

[68] BBN's entry into commercial networking was spurred by competition from three of their own engineers, who created Packet Communications Incorporated (and demanded the IMP source code). Some companies that were in the time-sharing business, like Tymshare, became network providers; large communications companies like Western Union and MCI also started to offer e-mail. Hafner and Lyon, *Where Wizards*, 232–34; Campbell-Kelly and Aspray, *Computer*, 295.

[69] IBM charged as much as $300,000 for processors to link its mainframes using its proprietary Systems Network Architecture (SNA). In the 1990s, routers using TCP/IP, which cost a fraction of the price, displaced SNA.

[70] On technolibertarianism, see, for example, Paulina Borsook, "Cyberselfish," *Mother Jones* (July/August 1996): 56, and at www.motherjones.com/mother_jones/JA96/borsook.html; Hudson, *Rewired*, 173–259.

marketplace—the Reaganite dream, the left nightmare—and spending weekends immersed in a cultural universe shaped by the sixties."[71] In that sense, the Internet of the 1990s may be the perfect synthesis of the anti-hierarchical cultural revolution of the 1960s and the anti-statist political revolution of the 1980s.

Yet this synthesis retains its own internal tensions and contradictions. While free marketeers today celebrate the Internet as the home of "people's capitalism," it also seems headed down the road to oligopoly. Three companies—the newly merged MCI WorldCom, Sprint, and Cable & Wireless—probably control three-quarters of the Internet backbone.[72] Web search companies, which are seen as the portals to the Internet, are busily gobbling each other up or being acquired by larger media conglomerates. Bill Gates's Microsoft Corporation has a pretty good chance of controlling not only all of the personal computers from which people access the Internet but also the browsers through which they read pages on the World Wide Web. And Intel Corporation is poised to be the manufacturer of choice for the chips at the heart of those computers.

Yet the road toward monopolization and centralized control is not preordained. The current antitrust cases against Microsoft and Intel—or, less plausibly, the revival of popular anti-monopoly sentiments—might alter the corporate landscape. In general, the tendencies toward both open and closed systems that have shaped the Internet from its origins remain with us today. On the World Wide Web, we can find web pages from every major corporation, but ordinary people still post their own pages with the same do-it-yourself enthusiasm as the members of the Homebrew Computer Club. (An astonishing 46 percent of web users have created their own pages, according to one recent survey.[73]) Most Internet servers run Unix or Windows NT, but a surprising number (and 3 to 5 million people overall) use a freely distributed operating system called "Linux," which itself incorporates crucial components developed by the Free Software Foundation headed by Richard Stallman, the MIT hacker who violated ARPA security. And the most popular web server software (Apache) and the most widely used programming language for web sites (Perl) are also "freeware." (Finnish programmer Linus Torvalds first put together Linux in order to get access to Usenet, where he chronicled his progress

[71] Mark Lilla, "A Tale of Two Reactions," *New York Review of Books* 45 (May 14, 1998): 7.

[72] On WorldCom, see Thomas E. Weber and Rebecca Quick, "Would WorldCom-MCI Deal Turn the Net into a Toll-road?" *San Diego Union-Tribune* (October 7, 1997): 11 (originally published in *Wall Street Journal*); Michelle V. Rafter, "WorldCom Bids for No. 1 Status," *Internet World* (October 6, 1997): and Barbara Grady, "Opposition Mounts to WorldCom-MCI Merger," *Internet World* (March 23, 1998), both available at www.iw.com/print/current/index.html. A major subsidiary of WorldCom and the world's largest Internet Service Provider is UUNET, which was founded in 1987 by the academic Unix user's group, Usenix, to sell access to Usenet; it later became a for-profit corporation and was bought by WorldCom in 1996. On the creation of UUNET, see Salus, *Casting the Net*, 177–78. The counterargument against monopolization of the Internet backbone is the rapid construction of new fiber-optic cables by companies like Qwest. In response to European and American regulatory pressures, MCI sold off its Internet backbone to the British company Cable & Wireless. But some Internet Service Providers still believe that MCI WorldCom will "wield too much power." Arik Hesseldahl, *Internet World* (June 15, 1998). For estimates of control of Internet backbone, see "Top Internet Backbone Companies," *Business Week* (July 20, 1998), available at www.businessweek.com/1998/29/b3587/123.htm.

[73] See Graphic, Visualization, and Usability Center of Georgia Tech, "8th WWW User Survey" (December 1997), reported at www.gvu.gatech.edu/user_surveys/survey-1997–10/#highsum.

in developing the software and sought help from other programmers.[74]) Commerce and advertising have infiltrated every corner of the Internet, but millions of people use the Internet to debate ideas or search for love in Usenet discussion groups, America Online chat rooms, and listservs. E-mail remains the single most popular application on the Internet. The degree to which a populist and democratic Internet survives and flourishes depends on larger social and political contexts. A revival of grass-roots democracy in other arenas of American (or international) life—as happened in the 1960s—will reinforce grass-roots democracy on the Internet (and not accidentally will make use of this medium to advance its causes).

The future remains uncertain. But it is clear that any history of the Internet will have to locate this story within its multiple social, political, and cultural contexts. This is particularly true since the Internet (in part because of its origins in the common language of binary digits and TCP/IP) seems to be emerging as a "meta-medium" that combines aspects of the telephone, post office, movie theater, television set, newspaper, shopping mall, street corner, and a great deal more.[75] Such a profound and complex development cannot be divorced from the idiosyncratic and personal visions of some scientists and bureaucrats whose sweat and dedication got the project up and running, from the social history of the field of computer science, from the Cold Warriors who provided massive government funding of computers and networking as tools for fighting nuclear and conventional war, and from the countercultural radicalism that sought to redirect technology toward a more decentralized and non-hierarchical vision of society.

[74] On Linux, see Glyn Moody, "The Greatest OS That (N)ever Was," *Wired* 5.08 (August 1997): 122 and following; and www.li.org/. On the Free Software Foundation and Stallman, see its web pages at www.gnu.org/fsf/fsf.html; and Richard Stallman, "Why Software Should Not Have Owners," available at www.gnu.org/philosophy/why-free.html. Andrew Leonard, "Apache's Free-Software Warriors!" *Salon* (November 20, 1997), available at www.salonmagazine.com/21st/feature/1997/11/cov_20feature.html. Torvald's Usenet postings are archived at http://x5.dejanews.com/profile.xp?author=torvalds@cs.helsinki.f i%20(Linus%20Torvalds).

[75] Phil Agre, "The Internet and Public Discourse," *First Monday* 3 (March 2, 1998), at www.first-monday.dk/issues/issue3_3/agre/index.html.

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