LEARNING FROM THE NET

BY EDWARD TENNER

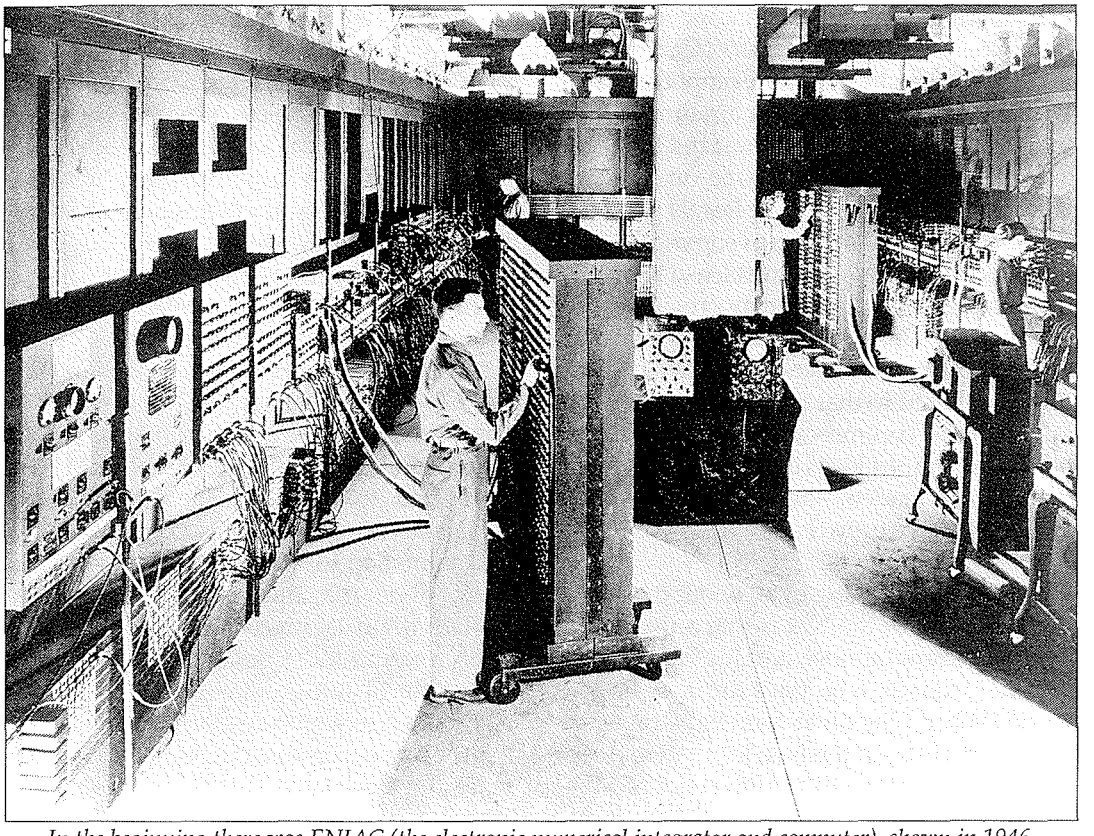
The end is NII. That's the National Information Infrastructure, of course, the amorphous web-to-be that has become an inkblot test of the national psyche. Some proponents dream of a 24-hour global symposium combining the best of Madame de Staël and Mortimer Adler, while skeptics fear a future of conference calls with the likes of John Wayne Gacy and Joseph Goebbels. Some fear a surveillance machine of the Federal Bureau of Investigation and Internal Revenue Service, others a witches' sabbath of hackers and virus artists. And while dreamers await a fiber-optic fountain of packet-switched wisdom, naysayers expect an overflowing bathtub brew of banalities, recycled programming, and junk messages. Glimmerings of all of these things are already visible.

What will the NII really be, whatever its ultimate name? The central problem of electronic futurism is that even the most gifted pioneers miss essential features of systems to come. That is inevitable. How can we know what is to be discovered and invented without discovering or inventing it? Paul Valéry pointed this out when he wrote in 1944 that "unpredictability in every field is the result of the conquest of the whole of the present world by scientific power." Even the legendary John von Neumann, one of the fathers of the computer, did not foresee small, personal machines. As a colleague of his has pointed out, von Neumann was interested mainly in developing machines for weather prediction. Yet many of the issues that will concern us for at least the next 10 years can already be seen in the operation of networks today. Much of this experience suggests that a National Information Infrastructure may be depressingly like real life.

The NII's promoters use a highway metaphor to describe it not only because the NII will allow individuals to travel hither and yon electronically but because the metaphor powerfully suggests other possibilities as well. Americans believe that an Infrastructure grows a Superstructure. Look what the interstate highways did. Americans are still willing to contemplate the prospect of immense wealth generated by something that has yet to be described or explained. We are all aware that hype is our birthright, that most of us are here because our ancestors believed equally extravagant promises. The fact that nobody knows how the NII will work or be financed is no great concern. Few people can describe all the workings of the Internet, but it works.

The real problems with the NII are in the Superstructure we expect. As to that, no one can safely say that an open, competitive order by itself will create the electronic promised land we hope to find. To the contrary, the benefits created so far by the Internet have come not from market-oriented firms but from enlightened monopolies and oligopolies, and these seem increasingly endangered just as the Internet is making their value clearer. Moreover, experience with the Internet today suggests that no matter what is done to promote access, electronic networking will promote elitism and secessionism as much as it does collegiality and community. The issues are, respectively, "depth" and "breadth." But first a few words about what today's Internet is.

In computer networking as in real life, results often do not have much to do with intentions. The free-spirited, cosmopolitan, decentralized Net was hatched under the wing of the Cold War eagle. It depends on a technique called packet switching: cutting up data into discrete, labeled units, sending them over high-speed lines by various routes,



In the beginning there was ENIAC (the electronic numerical integrator and computer), shown in 1946.

and reconstructing them for the recipient shortly before they reach their destination. If it is a highway, it is one in which vehicles and contents are dismembered, the pieces carefully labeled for reassembly, and each sent independently to be joined again in a single unit at the destination. The packet-switching idea was put into practice three decades ago by the Air Force-funded RAND Corporation as a safeguard against the collapse of defense-related communications in a nuclear attack or other emergency. There was no master switchboard; if one node went down, data could be routed around it. The first organization to use this system was the Pentagon's Defense Advanced Research Projects Agency (DARPA), which sponsored "Arpanet" at the University of California at Los Angeles in 1969 and expanded it through the 1970s. The network soon assumed a life of its own. In the early 1980s, Arpanet split into military and civilian networks, and the U.S. National Science Foundation (NSF) began to administer the Arpanet backbone. The NSF still contracts out the maintenance of lines and equipment to a variety of telephone, hardware, software, and service concerns.

During the 1980s three developments helped networking expand. First, the NSF insisted that all faculty and students at member institutions, not just those receiving NSF or Pentagon funds, have access to the network. Second, the adoption of the Transmission Control Protocol (TCP) and Internet Protocol (IP), already embraced by the Department of Defense in 1974, gave all Internet members a common method of sending and receiving data. Third, the organizations and committees in charge of the Net allowed new members—chiefly universities and other institutions—to

join at flat fees related to the number of users rather than the volume of traffic. Commercial information services such as CompuServe and Dialog can readily track the amount of time individual users spend on-line (and bill them accordingly). This is not done on the Net. Knowledge, the system implies, is good for you. Because most owners of copyrighted information are reluctant to release it in this freebooting realm, the Net may provide a very spotty view of human knowledge. But the Net is also available for extended use at a cost trifling compared to that of the commercial databases. The commercial sector is hard on browsers. The Net loves them—perhaps more than it loves readers—and that is one reason for its explosive growth.

The best thing of all about the structure of the Net is that a user need know almost nothing about who runs it, who pays for it, or how it works. When I log on to something on a faraway computer on the Net, let's say to a service called Gopher at the University of Minnesota, I am doing a number of things. From my home personal computer, connected by a modem to telephone lines, I am operating a sophisticated Sun computer in a nearby Princeton University building. (A dozen or more other users may be on-line at the same time, but each appears to have exclusive control.) That machine is linked to the university's high-speed Ethernet ring, one of two networks that circle the campus. Another Princeton computer then forwards my request to one of 19 regional centers around the country. Here the request, broken up into packets or units the size of a typed page of text, passes through dedicated fiber-optic lines to the regional center for Minneapolis, and from there to the right computer on the University of Minnesota system. Data flowing back to me from that computer follows a similar course in reverse.

The Minnesota Gopher can be imagined as a branching burrow offering the user a series of new menus. Each menu may offer from one to dozens of choices, or more. Each item may be as practical as a campus telephone book, as broad as a nationwide list of research library catalogs, or as cute as a mock dictionary of electronic smiley faces. Gopher—named after the university's mascot—is only a few years old, and it illustrates the fact that the wider and more powerful the Net becomes, the easier it is to use.

Convenience has made Net connections contagious. According to *Computerworld*, by 1994, 15 million users around the world were connected to the Net. The system's size doubles every year. And as graphics, sound, and animation supplement plain old text, the size of files transmitted is growing rapidly as well. (A digitized image for a book jacket can easily require more disk space—perhaps a megabyte of information—than the whole text.) The Net seems destined to become the main way corporations exchange data internally and externally. This is unsettling news for most of the people who have been regular users of the Net. While industrial laboratories have been members since the beginning, the Net is most uncorporate. Suits are not its strong suit. Users revel in individualism. They are proud of the absence of a central authority and, in many cases, of their ability to overcome whatever local authority or obstructions exist. Of course, that means investing a small amount of time, and often the result is that one simply finds more things to waste time on in the Net. But value is not the point. Freedom is.

The system works as well as it does for two reasons. First, at a cost of about $11 million annually the federal government modestly subsidizes the Internet backbone, the leased lines that connect regional centers, branching out to cover the entire country. Second, each Internet "site" is a network of its

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own, often with multiple servers (computers that supply end users' machines with programs and data), which are accessed by individuals using personal computers or work stations. Such decentralization has advantages. It allows academic departments, computer administrators, and others to make their own decisions about software and other matters, yet keeps the whole Net working together.

Behind the Net's usability and expansion is a paradox. Its agreeable anarchy rests on an efficient and unobtrusive (and largely informal) bureaucracy, just as the individualism of the American suburb and the romance of the open road require billions in tax and public works subsidies. The spirit of the Net may be self-realization through exploration of infinite possibilities and sources of knowledge. But the soaring fantasies of its users require untold subsidized person-hours. Holding up the Net is a corps of professionals paid by universities, government laboratories, and businesses, yet often doing work that benefits users elsewhere. The Internet would be useless to me and most other Princeton users, for example, if people in the university's academic computing and telecommunications departments did not troubleshoot the cables, upgrade the software, keep out the rogues (usually), and otherwise make the world safe for individualism. Other people at Princeton and other institutions develop and support the software that even proficient users need. Still others provide, free of charge, the amazing multifaceted contents of the Net: the endless supply of bibliographies and texts and data files and images. They need salaries, grants, and contracts. In other words, they need to be part of a well-funded organization.

Feast or Famine?

Thousands of discussion groups have blossomed on the Internet, a good number of them fairly exotic, as this sampler from the Chronicle of Higher Education *(June 1, 1994) suggests.*

"AACUNY-L" is for discussing Asian American culture and is available from LISTSERV@CUNY-VM.CUNY.EDU.

"ARL-ERESERVE" is for discussing electronic-reserve systems in libraries and is available from LISTPROC@CNI.ORG.

"HARRY-STINE" is for conversing with the author G. Harry Stine and is available from HARRY-STINE-REQUEST@ILC.COM.

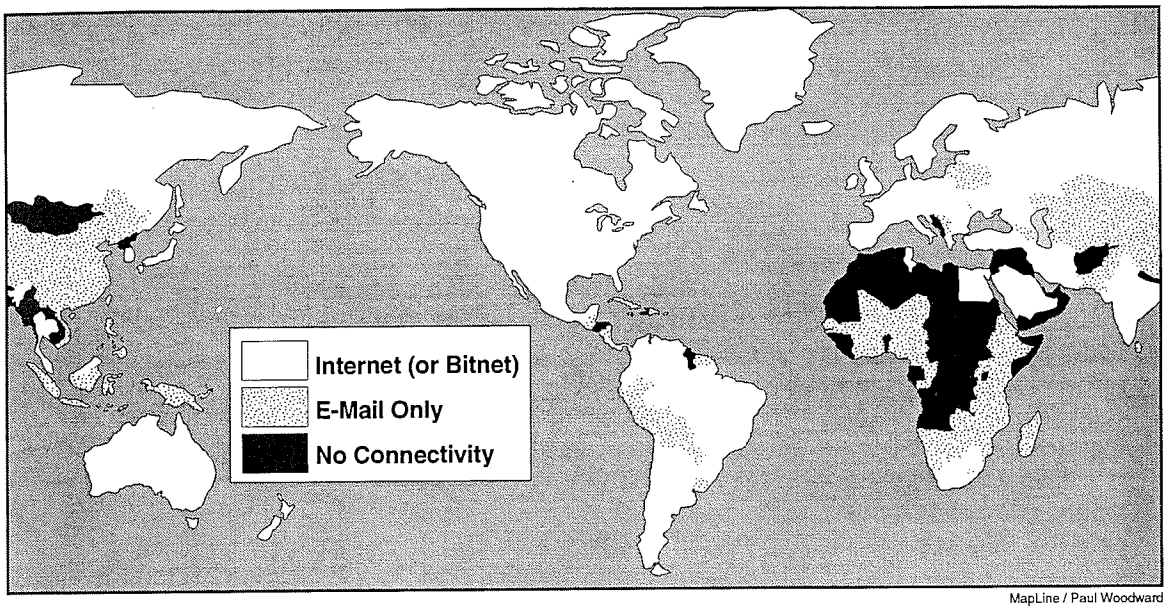
"MAXLIFE" is for discussing ways to work toward a positive, healthy life style that avoids heavy consumerism and is available from LISTSERV@GIBBS.OIT.UNC.EDU.

"PIANOMAN" is for discussing the life and career of the singer Billy Joel and is available from LISTSERV@PSUVM.PSU.EDU.

"SCUBA" is for discussing scuba and skin diving in either English or Turkish and is available from LISTSERV@CC.ITU.EDU.TR.

The software commonly used on the Net comes not from entrepreneurs but from big technological corporations and academia. Unix, the Net's basic operating software—the equivalent of the personal computer's DOS or Windows—is an industrial-strength operating system written for programmers, not end users. ("User" and "user friendly" have long been disparaging words in some programmer circles.) Unix is uncompromising and

Toward a Wired World



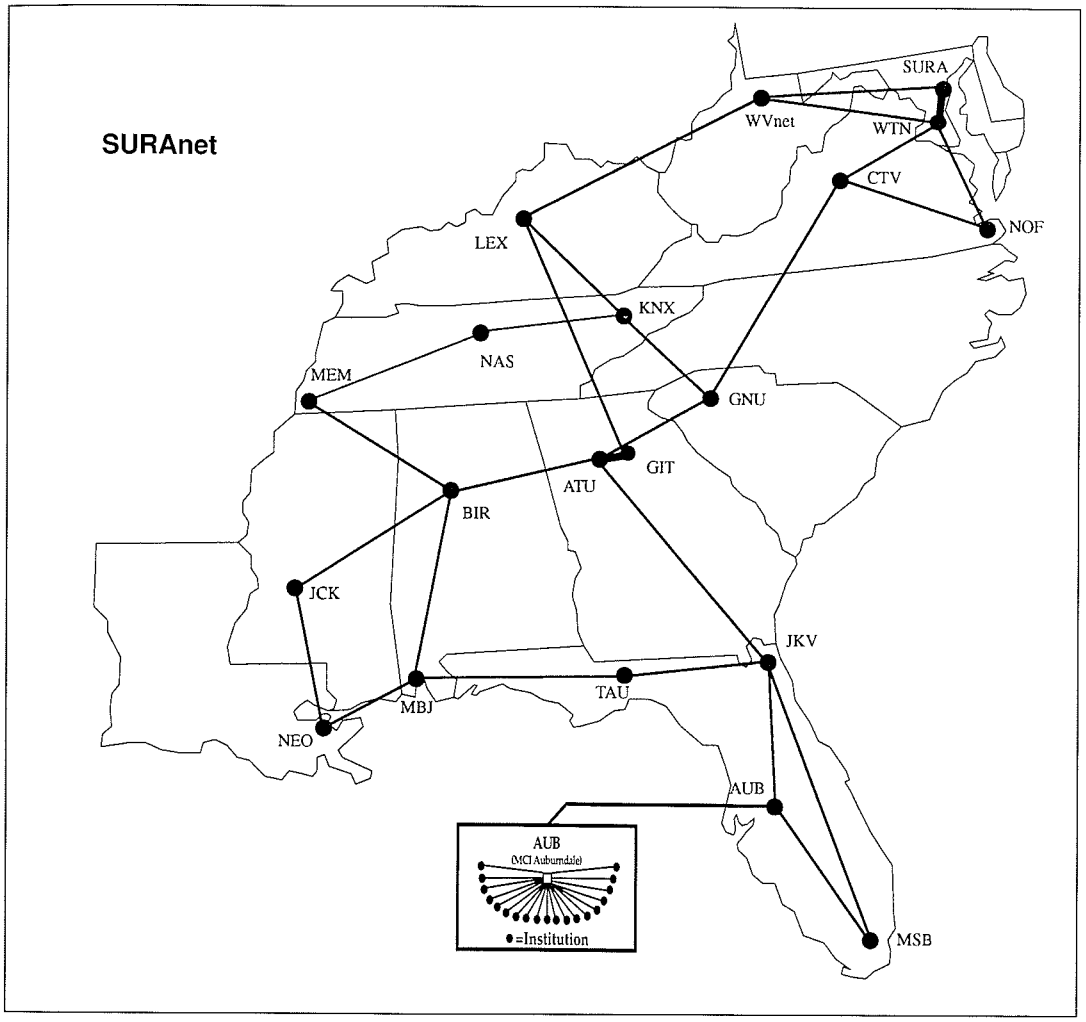
MapLine / Paul Woodward

A new network connects to the Internet every 20 minutes, but less than one percent of the world's population has access to it. (E-mail users cannot search databases or send or receive large files.) The map at right is a simplified view of SURAnet, a regional unit of the Internet. Individual users are not shown, only the institutional networks they are linked to. Information may travel any number of paths to get from one point to another.

unforgiving to the novice. On-line help consists of a stark, laconic glossary of commands mastered by trial, error, peer advice, and a growing number of third-party handbooks. But Unix is fast and effective once the user learns it. It should be. Bell Telephone Laboratories originally developed it for the operation of long-distance telephone switching. Barred by regulators from marketing it—these were Bell's monopoly days—the company gave the program away to educational users.

More recently, universities have developed Net programs on their own. From Columbia University comes the nearly indispensable Kermit communication software. From the University of Minnesota comes Gopher, the almost foolproof menu system for navigating the Net. The World-Wide Web (WWW) is an even more flexible and powerful system for doing the same thing. A click on a computer's mouse can point a user from one document to another source containing related information—possibly on computers thousands of miles away from the one containing the original document. The Web was developed for research at the European Particle Physics Laboratory (CERN) in Geneva, big science at its biggest and best. The Mosaic software that lets me access the WWW comes from the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana, another elite government-funded program.

What makes the Net so accessible, in other words, is research the public has funded in one way or another: not only through taxes but through ordinary payments for products and services, especially tuition and long-distance phone service. The cost of this research was always hidden in the prices of other things. It all seemed part of overhead, like new scales and postal meters for the mail room. Up to a point, it was. But by the



early 1990s, it had become clear that the whole Net had become much more than the sum of the parts.

Now that the Net appears about to go public, the depth that helped create it is increasingly seen by captains of industry and finance as a luxury and "curiosity-driven research" as a profanity. In real dollars, industrial research and development spending has stagnated since the late 1980s, according to one estimate. A few miles from my Princeton home, one of the country's greatest research organizations, RCA 's Sarnoff Laboratory, was devastated during the early 1980s when its main project, the videodisc, floundered. Other corporate laboratories are shadows of their former selves. More than ever, universities are the deep organizations of last resort for established researchers. But they have few career positions to offer young Ph.D.'s.

In the new age of the lean, "reengineered" corporation, depth no longer counts for much. We once resented the arrogance of big science, big government, big education, and big medicine. But we respected their competence and above all their commitment to planning and standard-setting. Even today, a battered IBM maintains specialized laboratories to test com-

puters for interference with other electronic devices so that airplane passengers, for example, can use their portable computers without endangering aircraft navigation systems. The second-tier suppliers and clonesmiths of the world cannot afford such high-mindedness. It is true that for all their contributions, big, proud, securely financed organizations are not always fun to work with. They offer few bargains. But they do have the luxury of assigning people to worry about standards, systems, and details. With secure market share, they can help out weaker firms and niche producers. They also can impose private and semipublic taxation systems in the public interest. Stiff rates for long-distance calls helped the Bell System keep local residential service cheap and reliable before its 1984 breakup. The British Broadcasting Corporation's license fees supported in-house symphony orchestras. The Ivy League's stratospheric tuition permits guaranteed financial support for low-income students. These attitudes and practices are what IBM, DuPont, Merck, and others have, at least in the past, shared with the British Museum, the former Soviet Academy of Sciences, the great universities, and at different times the Benedictines and Jesuits.

The fate of deep organizations may also have a powerful affect on the content that will travel on the NII—and, for that matter, via conventional media. Thin is a polite term to describe much of what is now produced. Creating innovative, exciting projects to feed the NII will be an immense challenge. Editors and producers already struggle to find good work in conventional form. Commercial media depend not only on the marketplace but on deep organizations, with their academic salaries, libraries, and computer centers. Even so, more and more high-quality books and documentary films have shifted from the commercial economy to more or less deep, subsidized, nonprofit institutions, such as university presses and public television. And these, too, are under financial pressure that new technology will not relieve. Somehow people have to be paid to produce new knowledge.

Financiers, journalists, and even customers once respected depth, even if they did not always like the haughtiness and conservatism that often accompany it. But depth seems to be waning, and nobody knows whether institutional leanness will turn out to be technological anorexia.

Can we substitute new broad structures for depth? Can a network take the place of deep organizations? Using programs like Gopher and Mosaic, can the newly empowered masses navigate their way to new knowledge and connections? Once more, the Net is all too much like real life.

For people who belong to an existing community, whether it is a corporation or a research project involving a dozen or more universities, the Net can be a powerful tool for collaboration. Yet as communication specialist Phil Agre has pointed out in a document widely circulated on the Net, the system does not alter certain fundamental human truths. Behind electronic communications there are still the same three-dimensional people, occupying the same points in space and time, and having the same power. The Net mirrors their social structure. An "alias group" of six, a dozen, 50, or more researchers or administrators seems to form a key social unit of the Net. They are another expression of what the sociologist Diana Crane has called "invisible colleges"—communities of researchers intensely concerned with the same problems, such as earthquakes in southern California. In general, the more prominent a person, the more likely that most of his or her time on the Net will be spent with these close electronic collaborators, not chatting with casual inquirers.

The reticence and indifference of much of the elite makes space for the rest of us, allowing the bright graduate students, postdoctoral fellows, and some assistant professors to shine. It encourages people from related fields to join discussions. But the silence of the Establishment also creates problems. On a science-

studies mailing list (an automated bulletin board for subscribers, sometimes open to all and sometimes not) I once saw a call for action against the Acoustic Thermometry of Ocean Climate (ATOC) for using sound waves to measure possible effects of global warming in the oceans. The author predicted ear injuries fatal to thousands of whales and other marine mammals. Disturbed, I consulted a colleague and through the Net he was able to search the resources of the Scripps Institution of Oceanography in La Jolla, California, and retrieve page after page of description and environmental defense of the project. Nobody at Scripps or elsewhere had posted a rebuttal to the original item on the list—they may not even have seen it. Somebody who relied only on the list would not have enough evidence. ATOC *might* still be hazardous to marine life, but the Scripps people had a good case that it would not be. Unfortunately, the case was not made when and where it should have been.

"On the Internet, nobody knows you're a dog."

Anonymity is a major feature of social existence in the on-line world, allowing users to shed, for better or worse, all manner of inhibitions.

There are excellent, balanced discussions on Net lists as well as dreadful ones. The expertly moderated Risks Digest (available as *comp.risks* on most systems offering news groups), one of the best, is an invaluable chronicle of cautionary tales and informed opinion on the hazards of computing. But in most lists, lacking participation by the best and most active minds in the field, exchanges may be irregular and turnover rapid. Flaming—the practice of sending scorching reproofs and rejoinders via E-mail—is less common than I had expected, but what might be called fading (just dropping out) is endemic. So are drift and fatigue. Where the Net excels is less in evaluating ideas than in pooling factual intelligence. It is a great place to get suggestions for a reading list on almost any subject. If one needs a reference on the origin of left- and right-hand driving rules, on the location of a 19th-century French artist's papers, on the refraction of light through water, or on Aristotle's rhetorical terminology, the Net is superb. But it is an impractical substitute for any other form of learning, and is likely to stay that way.

The real test of breadth, though, is not the experience of academics, writers, scientists, and technical people in discussion groups. Most of these people are connected in some way with a deep organization, even if they are independent professionals or entrepreneurs. Nor is it the medical use of networks. What the Clinton administration wants is much broader: access for

all citizens and connections for all primary and secondary schools. If the old AT&T was the ultimate deep organization, the American public schools are the consummate broad organizations, curiously like the Net in their loose coordination and grouping in autonomous districts.

Americans are proud of depth but not always convinced it pays. They are even prouder of breadth, though, and the political support for the NII shows it. In a December 1993 speech, Vice President Al Gore declared that "broadcasts, telephones, and public education were all designed to diminish the gap between haves and have nots" (a debatable assertion), that the NII should do the same, and that "schools and our children are paramount." He went on to call for giving "every child access to the educational riches we have in such abundance."

Admirable as the idea of wiring all schools sounds, it is financially not a simple thing. As the vice president himself noted, only one-quarter of all schools possess even a single modem, even though one can be had for about $100. And wiring and hardware are only a small part of the true cost of computerizing. Far greater costs accrue in the time specialists spend installing, maintaining, and debugging equipment and software. Computer prices may be dropping, but these hidden costs of computing are not. Indeed, some have been rising sharply as hardware and software manufacturers discontinue free telephone support services for customers.

Setting aside such difficulties, the real challenge to breadth is the character of the educational software on the future NII. Vice President Gore seems to assume that this material already exists in "abundance." But does it? True, vast amounts of literary, scientific, artistic, and musical material can now be transmitted electronically, and more will certainly become available. Even at today's prices, a book can be scanned and digitized for under $10; a library of 10 million volumes could be scanned for a price modest by Washington standards. In the near future, students presumably will be able to download great books, hear symphonies, visit the great art galleries of the world, and so forth. But the vice president may be missing the point.

Using any resource demands what social scientists call "tacit knowledge": skills and ideas that may not be recorded in written form but that arise from person-to-person learning and experience. One of the functions of computer networking at the highest professional levels is to draw on just this kind of experience. An expert radiologist, for example, may see patterns in a nuclear magnetic resonance scan sent over the Net that most other physicians would probably overlook. My colleagues in structural geology and geophysics can see things in plots of seismic data that elude even many experienced petroleum geologists. The Net lets people with a high degree of tacit knowledge share it with others at similar levels.

The anthropologist and computer writer Bryan Pfaffenberger shows in *Democratizing Information* (1989) that even for adults, using on-line information depends on tacit knowledge acquired through personal interaction, information and skills that may not be documented anywhere. Someone beginning to study a subject, whether as a schoolchild or an

The E-Mail Crisis

More than half of all traffic on the Internet is E-mail, and much of that is inconsequential chatter. After raising the subject of electronic communication in the New Yorker, *writer John Seabrook was deluged with E-mail, including the missive below.*

From: peter911sc@aol.com

Real problem with the Information Superhighway is typified by this letter: God only knows how many idiots like me will tie up your time with responses.

adult, needs these hard-to-define abilities. Learning any game or skill requires immersion in a group of people who already have the skill. Weight training can improve an athlete's game, and a flight simulator can sharpen a pilot's abilities, but machines cannot develop a skill that is not already there.

Networked information can develop and extend skills that have already been taught by schools. And many computer operations are becoming important skills in their own right. It is another thing, however, to expect networked software to replace the social world of the school as a social order of teachers and learners. We do not really know what learning is, and we do not understand why some people are so much better at teaching and learning than others. We certainly do not know how to teach a computer to teach. By brute force, today's dedicated chess computers can defeat even grandmasters in the speed game. What programs alone still cannot do is tutor an average beginner to expert level. Even if the same material is available free to all schools, students without a strong basis in tacit knowledge will benefit far less than those who have it. If the haves and have-nots are treated equally, then the gap between them will probably grow, not shrink.

When it comes to building better software for a future Net, educators are likely to find another unpleasant surprise. The better and more powerful the hardware and the greater the network bandwidth, the more expensive software may be to produce. As the historian Steven J. Ross has pointed out, the improved production values of motion pictures after World War I increased costs and helped concentrate power in major studios. Labor unions and political dissenters had far fewer opportunities to get their views into national distribution. While improving the medium, technology had helped multiply producers' expenses. In the 1990s, movies with spectacular electronic special effects, such as *Terminator 2* and *Jurassic Park*, have had the biggest budgets. Educational animation and sound are unlikely to reach the same stratosphere of cost, but software development remains both labor intensive and risky; some of today's acclaimed educational CD-ROMs have sold only a few thousand copies. The outlook for high-quality products is good, but they will not be cheap, and in one way or another they will need heavy public financing, especially if equity is a concern. How will schools that can barely afford almanacs pay for on-line multimedia software?

If the deep organizations that developed the Net are in trouble and the broad organizations do not yet provide the base that can take advantage of it, what can the future of an NII be? We already have multiplied our ability to communicate and to collaborate. Our problem, and the challenge of any future network, is that we have multiplied it all too well. Communication is the only thing in society that risks self-destruction as it is multiplied. Imagine an Infotopia in which any person or organization could send a multimedia file of any size to anyone else, at almost no charge. Infotopia would collapse almost instantly. Many people already resent junk E-mail and incipient advertising on the Internet. Newsgroups, the discussion forums that are probably the best-known feature of the Net, are already dangerously unwieldy just because of the growing volume of traffic. That does not mean the Net itself is going to collapse, but only that selection and self-selection are going to grow.

It might be time to think again about the overused but unavoidable superhighway metaphor. Roads and networks do have something important in common. Both make it easier to work with people dozens, hundreds, or even thousands of miles away. And both thereby give you an alternative to getting along with the people next door. You can get out of uncomfortable situations. You can limit your visits to people who share your interests, biases, and outlook. And if your new space becomes unpleasant, why, you can move again. Building suburbs and exurbs is

not so different from building networks.

Yes, networks can help people strengthen neighborhoods and communities. But they also encourage people to find ways out. Unhappy with your schools? Join the parents who have turned to home schooling. Teaching materials and mutual support are already available on-line, and home educators have been using electronic mail effectively to organize and lobby for their rights. Their children may learn all they need to, but the economist Albert O. Hirschman has pointed out that when the most quality-conscious users are free to leave a troubled system, whether railroads or schools, the system suffers further by losing its most vocal critics. Any future information network will help unhappy people secede, at least mentally, from institutions they do not like, much as the interstate highway system allowed the affluent to flee the cities for the suburbs and exurbs. Prescribing mobility, whether automotive or electronic, as an antidote to society's fragmentation is like recommending champagne as a hangover remedy.

Equality, like community, can also be elusive. We have seen that much of the real business of the Net is invisible to most of the people on it, not through elitist conspiracy but through operational necessity. It turns out to be not an alternative world but an extension of the conventional world and its hierarchies. For example, the Net in its majesty grants to the faculties of rich and poor universities equal electronic means for filing grant applications, but if government panels include affiliation snobs (as they often do), all the equal access in the world will not help the first-rate applicant from the second-rate school. Electronic networks, like highways, may bring you to the door but won't necessarily let you in, or upstairs.

Why are so many people ill at ease with the administration's proposals for telecommunications law reform? It's because of the assumption that more flexible regulation will unleash investments that will open a cornucopia of knowledge. It's because of the claims that a system can assure universal affordable access *and* respect copyright as we know it. But above all, it's because of the tendency of communication to divide people as effectively as it unites them. What desperately needs attention is not tomorrow's infrastructure but the knowledge base, in depth and breadth, on which it will depend.