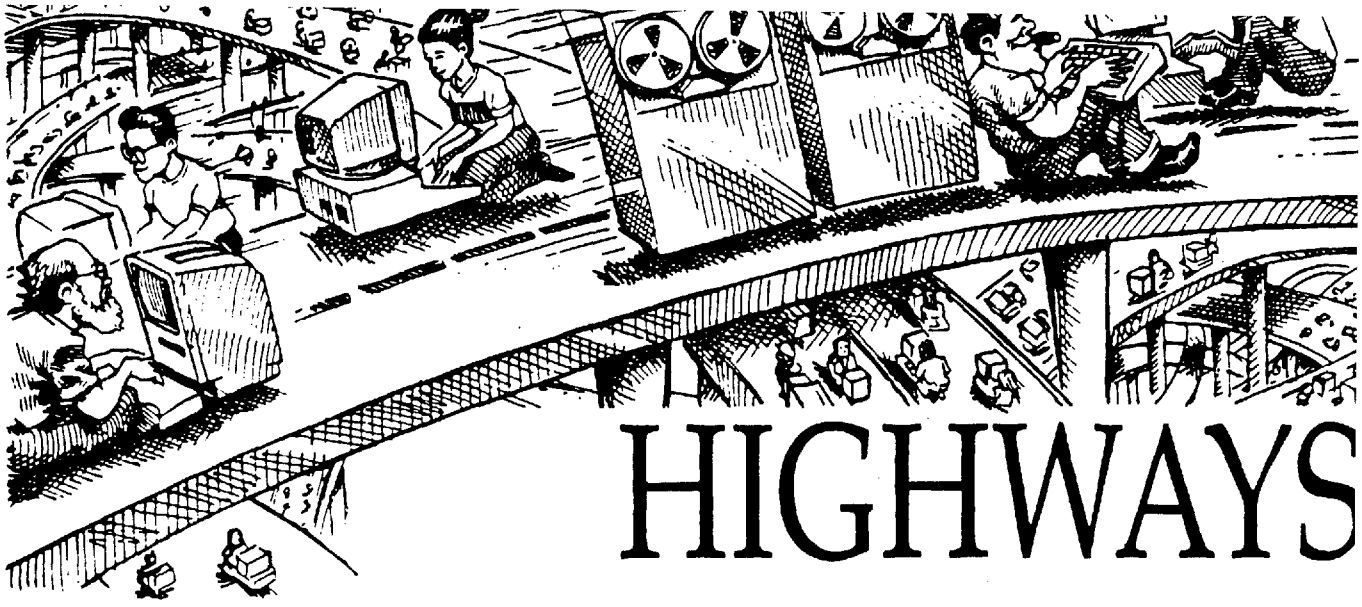


HIGHWAYS

BY ROGER KARRAKER

This is not an article about technology. It's an article about human needs. For example:

- *A doctor telecommunicates a CAT scan from her small hospital to the nearest major medical center.*

- *An MIT professor uses his desktop computer in Cambridge to tutor a talented young physicist on a reservation in rural Montana.*

- *Biologists scattered around the world exchange data on an hourly basis, coordinating their effort to map the human genetic code.*

- *A grassroots political organization gets the word out about a meeting, just in time to mobilize for a municipal legislative session.*

Each of these activities, science-fiction-like as they might sound, actually are happening today, courtesy of computer-mediated telecommunication networks. The future of this technology is a matter of much behind-the-scenes maneuvering. Roger Karraker, instructor in journalism and Macintosh at Santa Rosa Junior College, has teased out the key issues from a politically and technically complex debate.

— Howard Rheingold

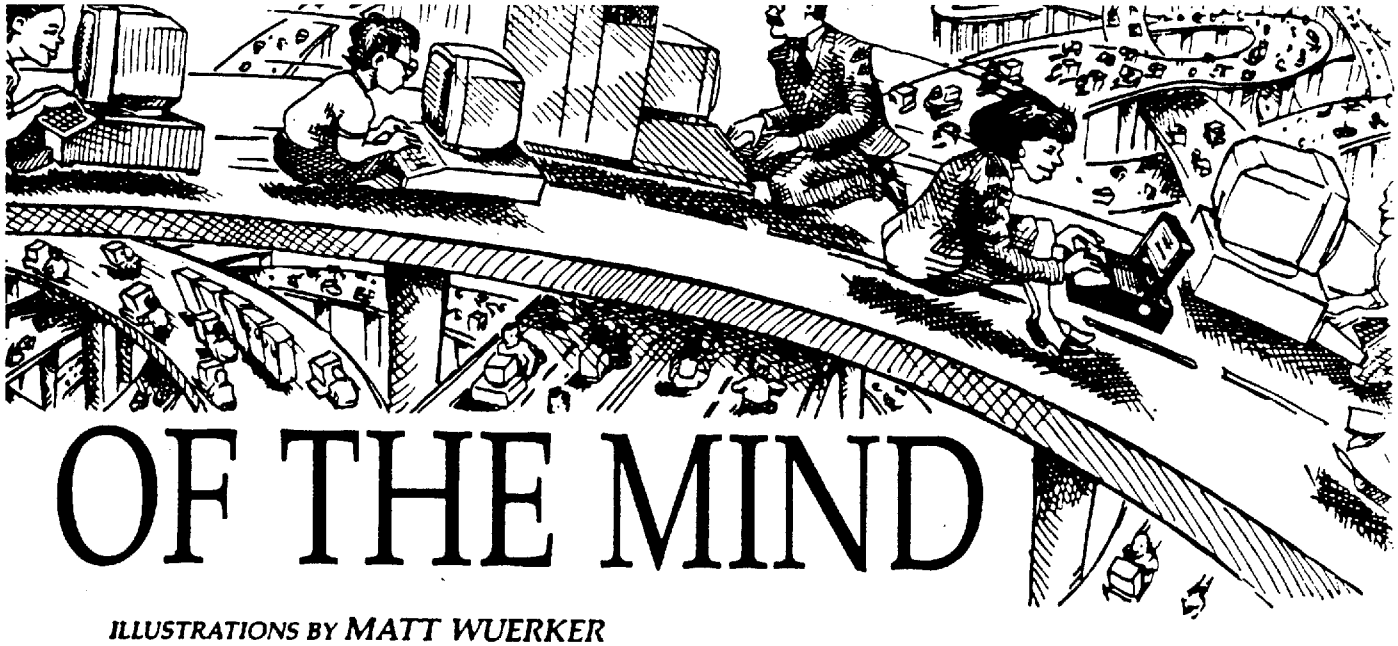
A QUIET BUT CRUCIAL debate now under way in Congress, in corporate boardrooms, and in universities, has the potential to shape American life in the 21st Century and beyond. The outcome may determine where you live, how well your children are educated, who will blossom and who will wither in a society in which national competitiveness and personal prosperity will likely depend on access to information.

This battle is about who will build, own, use and pay for the high-speed information networks of the future and whether their content will be censored. These data highways, capable of transporting entire libraries coast-to-coast in a few seconds, joining millions of people into communities of interest, or sending crucial CAT scans from remote villages to urban specialists, could be linked in a vast network of "highways of the mind."

The backbone of these communication networks will be built of fiber optics, hair-thin strands of glass that transmit digital signals thousands of times faster than ever before. In addition to their speed, fiber optics bring an environmental bonus: they are made of silicon, the earth's most common element, and the growing use of optical fibers will reduce demand for cables composed of copper, an element whose fabrication causes much environmental damage.

Futurist Alvin Toffler says the future of the United States depends upon the creation of these networks: "Because so much of business now depends on getting and sending information, companies around the world have been rushing to link their employees through electronic networks. These networks form the key infrastructure of the 21st Century, as critical to business success and national economic development as the railroads were in [Samuel] Morse's era."

These data highways connecting schools, colleges, universities, re-



OF THE MIND

ILLUSTRATIONS BY MATT WUERKER

searchers and industry could help create high-quality education in the smallest schools, or start a society-wide revolution as important as the invention of printing.

Conversely, if access to such data networks is restricted to those who already have money, power and information, then these networks might become nothing more than a classic case of economic imperialism, taxation without communication, that one critic has dubbed "toll roads between information castles."

Virtually all sides to the controversy agree that such networks are essential. The future belongs to those who have ready access to huge amounts of accurate information. The Japanese government and industry are actively building such a network. The Japanese government estimates that in 20 years, 35 percent of Japan's gross national product will be dependent on information that flows across this web.

In the United States there is only a vague consensus that this high-bandwidth network is vital. In place of the unity of purpose evident in Japan, there is internecine squabbling over who has the right to do what/to where/to whom.

Four Questions

At issue are vastly different visions of the roles of government, education, and corporations. Four key questions dominate the debate:

1. Who will build the network? (Will the federal government create the infrastructure or will it be left to private enterprise?)

2. Who will have access to network services? The debate here is between those who would restrict the network's services to the nation's research leaders and those who believe in access for anyone with a modem.

3. Who will pay for all this? Everyone concedes that the government will pay the lion's share of getting the network underway. But should it do so by directly funding the infrastructure or by paying the user fees for the big research organizations working on federal projects?

4. What kind of information will be allowed on the network? If the federal government owns the network, the First Amendment is in place and unpopular speech and art will be protected. If private enterprise owns and runs the network, the future of freedom of electronic speech is less clear. A corporation owning the network could censor discussion of controversial topics.

Two analogies — "highways" and "railroads" — have been proposed to frame the debate. Both borrow from transportation examples in U.S. history. Both, I believe, fall short of the mark. With a little tweaking of the two, the best solution for the U.S. might be found in a kind of synthesis of these different visions.

The Interstate Highway Model

One vision, championed most visibly by Senator Albert Gore, is to create a National Research and Education Network (NREN) that will link the nation's top scientific, educational, corporate and governmental researchers. Gore's bill to create NREN died in the last Congress but was re-introduced in January, 1991 with more coordinated support among governmental agencies. The NREN proposal is just one part of the government's five-year, $2 billion High Performance Computing Program, which includes supercomputers, software,

networking and education. A Senate vote is expected in spring 1991, with House action and a presidential decision to follow.

Gore speaks of a "catalyst" role for the federal government akin to the creation of the interstate highway system in the 1950s. The interstate transportation system was seen as a national resource and tax monies were used to finance the infrastructure, which benefited all Americans through far-flung, decentralized distribution of goods and services.

The highway model — government recognition of the communications infrastructure as a vital national resource — is the norm throughout Japan, Europe and most of the world.

The Railroad Model

IBM, MCI and other private firms prefer a different model: private enterprise and quasi-monopolies such as America's railroads of the 19th Century.

The decision to give private transportation monopolies to the railroads and let them determine the nation's destiny created the 20th-century landscape of America. Not surprisingly, towns and farms accessible to the railroads prospered and grew. Areas ignored by the railroads withered and died.

The public and the government weren't consulted; private interest, not national interest, determined who got what. It was pure free-market capitalism, with no government regulation and no direct governmental investment, and it led to some ugly excesses. Yet at a time when federal budget deficits approach $300 billion per year, the idea of letting private enterprise foot the whole bill is powerfully attractive.

And that is essentially what IBM, MCI and Merit, an agency of the state of Michigan, have proposed. Last September they formed ANS (Advanced Network Services), a not-for-profit joint venture that proposes to build, finance, maintain, and operate a private network. But the government would need to guarantee that research institutions had annual budgets sufficient to pay their ANS bills.

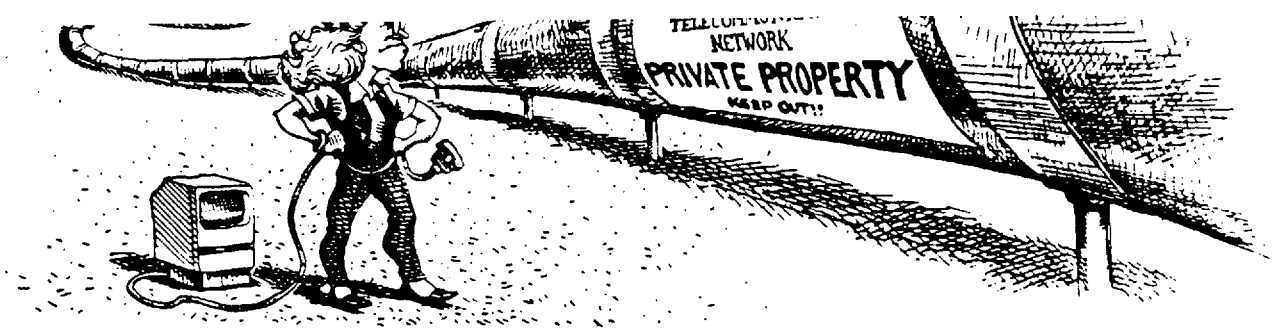
Why Decide Now?

The existing national research communication system is woefully inadequate to today's needs and must be updated soon; this technical obsolescence lends urgency to the need for finding answers to these policy questions.

The question is how best to modernize and expand the DARPA/Internet network. In the late 1960s, the Defense Department's Advanced Research Projects Agency (ARPA) created a network of telephone lines connected to large research institutions in government, education, private enterprise, and the military to allow researchers to exchange computerized information.

Over the next decade and a half, the number of researchers grew significantly. As computers grew more powerful and easier to use, researchers outside the computer sciences began to use remote terminals and telecommunication networks to exchange messages and share computing resources from their homes, offices, and laboratories. Each research center supported dozens or hundreds of users, and each local center was plugged into the overall network; thus, both the number of nodes in the network and the number of users at each node proliferated. The number of regional networks in government, business and education skyrocketed, as did connections to ARPAnet's main lines, or "backbone." Most importantly, the type of data exchanged by researchers changed dramatically. Where simple electronic mail messages had been sufficient, collaborators across the nation now needed to exchange high-density data — sounds, graphic images, even video images.

By 1987 the ARPAnet suffered data gridlock and the last of its 1970s state-of-the-art lines (56,000 digital "bits" per second — about 50,000 words per minute) was laid to rest. ARPAnet's successor is NSFNET, funded until 1993 by the National Science Foundation, another government agency. NSFNET's original lines were so-called T-1 or 1.544 million bits per second. These lines lasted just three years, and are now being replaced by a newer T-3 (45 million bits per second) backbone — another 28-



fold increase. No one expects it to last for long.

The growth of the Internet — those machines connected to the NSFNET backbone — has been phenomenal. In 1989, the number of networks attached to NSFNET/Internet increased from 346 to 997; data traffic increased fivefold. The latest estimate, itself probably wildly out of date, is that 100,000 to 200,000 computers are directly connected to NSFNET, with perhaps a total of two million individuals able to exchange information.

For example, the WELL, Whole Earth's computer conferencing system, is not connected directly to either the NSFNET backbone or the Internet of sites on the backbone. But the WELL's computer is linked to Apple Computer's mainframes, to Pacific Bell's computers, and to the University of California — all of them on the Internet. So the WELL's 3,500 customers can send electronic mail to millions of other computer users around the country and, via connections between the Internet and other countries, all around the world.

NSFNET's phenomenal growth in 1989 was, evidently, just a prelude to the data deluge that is now in full flood. Traffic more than doubled between September 1989 and September 1990. It is projected to double again this year. It won't take too long to exhaust even those T-3 lines that carry 800+ times the data of the pre-1987 lines.

That's where the NREN proposal comes in. As proposed by the Coalition for the National Research and Education Network and championed by Senator Gore, Congress would authorize the network and provide $400 million over five years to put it in place. The universities and research centers would pay the additional costs for local area networks that would connect their scholars to the network.

When completed in 1995 the network would have a 3-gigabit backbone —3 billion bits per second, a 66-fold increase over the current T-3 capacity, a 50,000-fold increase over the old ARPA lines. That's about 300 million times faster than the clattering state-of-the-art teletypes I used at the Associated Press a quarter-century ago.

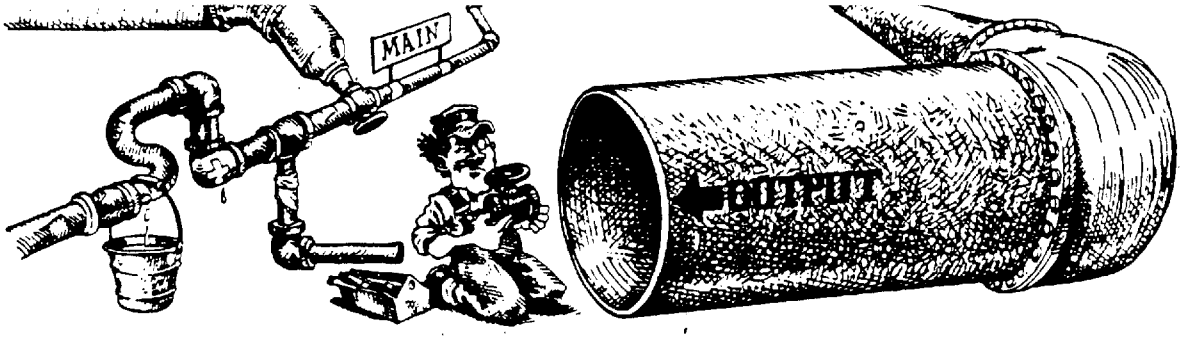
From CAT Scans to Instant Encyclopedias

What can you do with 3 billion bits per second? The NREN Coalition likens this transmission capacity to sending 100 three-dimensional x-rays and CAT scans every second for 100 cancer patients, or sending 1,000 satellite photographs to researchers investigating agricultural productivity, environmental pollution or weather prediction. Reduced to just words, it would be 100,000 typed pages per second, or as the Coalition dangles tantalizingly before us, "making it possible to transmit the entire Encyclopædia Britannica in a second."

Before you begin salivating at the thought of every book, every magazine article available instantaneously at your slightest whim, here's the rub: as currently designed, NREN's 3-gigabit data lines aren't coming to your house, or your kids' school, even your local library. NREN would connect only the largest research universities and consortia, at least one in every state. From there, lower-speed regional networks would connect nearby institutions. At the bottom of NREN's proposed three-tier system would be local college and university networks. There's no plan or provision for K-12 schools or local libraries in the NREN proposal.

WHAT can you do with 3 billion bits per second? The NREN Coalition likens this transmission capacity to sending 100 three-dimensional x-rays and CAT scans every second for 100 cancer patients, or sending 1,000 satellite photographs to researchers investigating agricultural productivity, environmental pollution or weather prediction.

One doesn't need the vast capacity



of NREN to exchange simple electronic mail. There are many alternative, if slower, networks available. Using supersophisticated NREN for such mundane tasks might be like trying to get a drink out of a fire hose. And it's problematic whether local schools and libraries would be able to pay for the equipment needed to exchange items much more complex than simple electronic mail. But there is the potential here for the creation of information haves and information have-nots. As Apple Computer librarian Steve Cisler puts it, "If this is going to be a data superhighway, how would you like to have to drive to a computer company, military base, or university to find an onramp?"

Dave Hughes, a Colorado telecommunications pioneer, takes a more cautious view of the slimmed-down NREN that Gore and others are trying to push through Congress. An ex-Army colonel and former aide to Defense Secretary Robert McNamara, Hughes believes that NREN's plan, with local schools not even mentioned, could perpetuate educational elitism, where already-prosperous research universities get additional taxpayer-paid subsidized service and already-poor local schools get short shrift.

Which doesn't mean that Dave Hughes doesn't want to see a high-speed data network. He wants one that will reach every corner of America, terminating in (at least) each of the 16,000 local school districts. Such as the 114 one-room schoolhouses in Montana that he and Frank Odasz of Western Montana College have managed to connect up, after a fashion, through their Big Sky Telegraph system, and from there out to the rest of the world. Through this system, a theoretical physicist from MIT has been able to teach a course in chaos theory mathematics to students in these schools — which the physicist cannot do through the Internet workstation on his MIT desk, Hughes says. Hughes and Odasz already have created a grassroots online culture in the wide-open spaces where physical isolation reinforces the lack of ready access to national sources of information.

Hughes wants either to flatten NREN's three tiers of service into a single tier, or have guarantees of affordable access and compatible communication between the three tiers to and from every educational/political subdivision in America. From observing online behavior nationally for the past 11 years, he thinks talent will find its own level on the network, and that those with neither talent nor motivation will be satisfied with local bulletin boards and video games. He believes all schools in the country should have the right of access under law, with either affordable rates or appropriate subsidies.

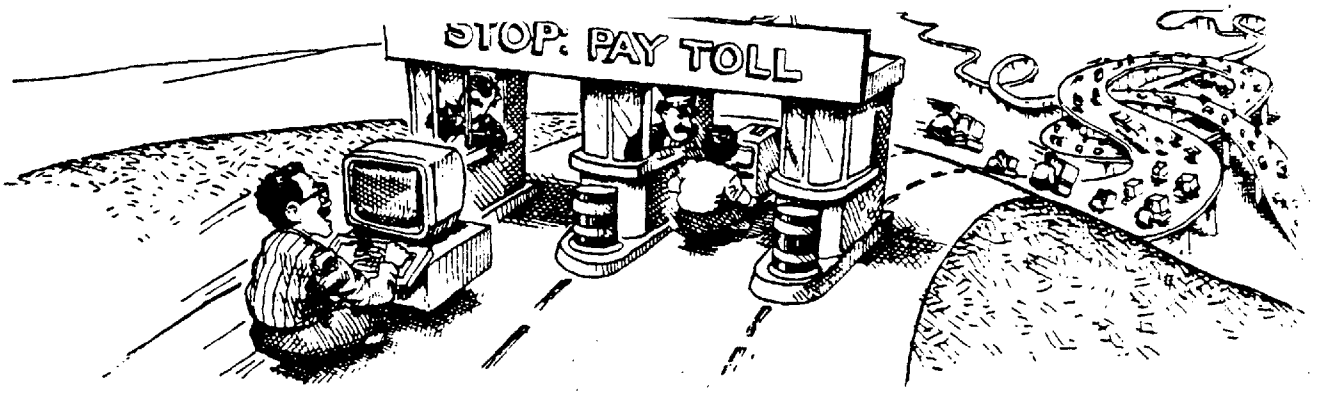
"The implicit assumptions behind the NREN proposal," Hughes says, "are that it will only link large research (which also may be 'educational' in the sense of higher education) institutions. As currently conceived, NREN will not extend to the 16,000 K-12 school districts in America, much less foster the vision of a nation of people learning all their lives by mixing institutional (edifice-centered) education and training, and learning, formally and informally, from home, library, place of business or study.

"So the metaphor of the need for 'Highways of the Mind' across this land is very deceptive. It really could turn out to mean 'Super Toll Roads between Castles.' That is not my vision of a Network Nation."

The Network Nation

What would a real Network Nation be like? Conservative theorist/author George Gilder, like Hughes, foresees a renaissance in education caused by the merger of fiber-optic telephone service to the home and new ultrapowerful multimedia computers.

"The telecomputer could revitalize public education by bringing the best teachers in the country to classrooms everywhere," Gilder says. "More importantly, the telecomputer could encourage competition by making home-schooling both feasible and attractive. To learn social skills, neighborhood children could gather in micro-schools run by parents, churches or other local institutions. The competition of home-schooling would either destroy the public school system or force it to become competitive with rival systems. . ." High-speed data communications to the home might also revolutionize where and how we live. Data communications



could allow rural telecommuting, ending two centuries of "brain drain" from the countryside to the cities.

Gilder says, "Every morning millions of commuters across America sit in cars inching their way toward cluttered, polluted and crime-ridden cities. Or they sit in dilapidated trains rattling toward office towers that survive as business centers chiefly because of their superior access to the global network of computers and telecommunications. With telecomputers in every home attached to a global fiber network, why would anyone commute? People would be able to see the boss life-size in high-definition video and meet with him as easily at home as at the office. They would be able to reach with equal immediacy the head of the foreign subsidiary or the marketing chief across the country. They would be able to send and receive documents almost instantly from anywhere."

Who Pays the Bill?

Whether it's the $400 million Gore's NREN bill calls for or the untold billions required for fiber optics to the home, high-speed data communications will cost a bundle, and the major political battle is over who will pay.

For Gilder, and for many of us who hope to benefit from a national information network based on fiber-to-the-home, the answer is clear: let the local telephone companies install fiber to every home, amortize the cost and add it to our monthly telephone bills.

To consumer groups and many state public-utilities commissions, that reeks of reverse Robin Hood-ism: stealing from the poor, retired and elderly who may never be able to utilize the capabilities of the new system in order to subsidize corporations, universities and a well-educated few. Indeed, that's already underway. Much of the U.S. telephone system, especially in the central cities and along corporate "data corridors," has already been converted to fiber-optic service and the costs rolled into the local telephone rate.

Another option: last September IBM and MCI, who already operate NSFNET under contract, proposed to build a "private Internet" backbone that would require less governmental funding, but would involve user fees. Advanced Network Services, the IBM/MCI nonprofit joint venture, would build and operate the network.

The benefit, as IBM exec Allan H. Weis, president/chief executive officer of ANS, puts it, is "Because we are broadening the community of those using the network, the fixed costs of national networking will be more widely distributed. This will free up funds which could then be allocated to assist the neediest organizations to connect to the national network, as well as to continue to support and enable the national network to remain in the vanguard of new technology."

"MORE importantly, the telecomputer could encourage competition by making home-schooling both feasible and attractive. To learn social skills, neighborhood children could gather in micro-schools run by parents, churches or other local institutions. The competition of home-schooling would either destroy the public school system or force it to become competitive with rival systems. . . ."

That doesn't sit well with Dave Hughes. "With this administration, the budget crunch, and general ignorance of the implications, I'm afraid that the decision makers — including Congress — will welcome 'private enterprise' with open arms. And overlook such minor details as 'equal access.' No, it will be 'If you got the bucks you can buy it.' Kiss off the idea that all K-12 schools will have 'educational' access." →

Mitch Kapor, the cofounder of Lotus Development Corporation and president of the Electronic Frontier Foundation, also believes that universal access should be a central tenet of any national network policy.

"Whatever infrastructure we create," Kapor says, "should incorporate a notion of 'universal digital service,' much as AT&T pioneered, and which later became national policy, with respect to voice telephony in the early 20th Century. Everyone should be able to connect to the net."

Hughes and Kapor approach the NREN controversy from somewhat different perspectives. Hughes is suspicious of turning the nation's infrastructure over to the agendas of private enterprise.

As Hughes terms it, "I am concerned about the U.S. mind-set which, without thinking, says that the 'private sector' should provide telecommunications in the U.S. simply because that is the way it always has been, while in a couple other key areas — sewage, highways, and education — that is not the case.

"If we believe so mightily that our national future is very much wrapped up in computing and telecommunications — and that especially 'research and education' are going to have to be improved mightily for us to compete — then we ought to be thinking a lot more carefully than we are now about which portion of telecommunications should be government-provided/subsidized/regulated and which portion pure profit-and-loss commercial."

Kapor suggests that one way to satisfy both Big Scientists and Universalists is to have, in effect, two networks, achieved by "overlaying" lower-bandwidth networks onto an NREN-like backbone.

Kapor cautions, however, that no technical fix is going to resolve the policy controversies: "These high-end and low-end visions of the NREN are strikingly different. There is no assurance that one size network fits all. In principle, it might be possible to satisfy everyone with one technical scheme; in practice, this is unlikely. Some important public-policy choices therefore need to be made, one way or the other," he says.

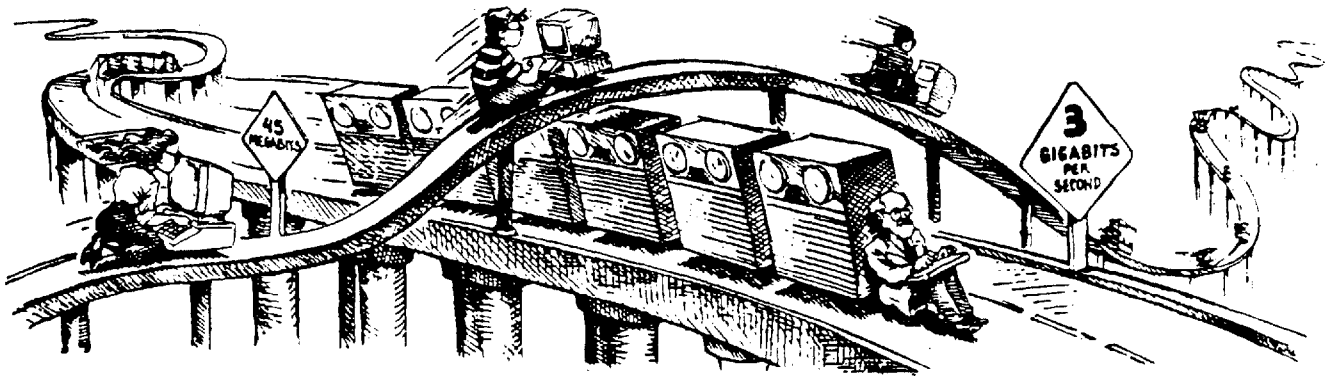
While he lauds the IBM/MCI/ANS group for its donations of millions of dollars to NSFNET computing, Kapor is concerned that ANS policies may become, by default, national policies concerning telecommunications without the benefit of public debate. ANS, he says, is already establishing policies for measuring network traffic, billing and accounting, and setting access charges for new information entrepreneurs, all without the normal hearing and rule-setting process required of public utilities.

"What ANS does in the way of setting up commercial access to the national information infrastructure may well become, in effect, national policy," Kapor says. "But there is no guarantee of public accountability.

"We are dependent on the continued good will of ANS in setting its policies. We don't know, for instance, whether the technology for counting traffic on the net that ANS develops will be as enabling for would-be information entrepreneurs as it will for big corporate information providers. Without an open public process for getting input in the development of the net, the resulting choices are less likely to be in the public interest."

Kapor also sees that a purely private enterprise such as ANS may not be fully consonant with the Electronic Frontier Foundation's goals, including First Amendment guarantees for electronic speech and guaranteed access to communications services at fair prices. EFF's newsletter has noted that Prodigy, a national computer communications system half-owned by IBM, has been embroiled in disputes because of its policy of reading and censoring postings made to Prodigy's public forums.

"I believe it's important to establish the legal principle that businesses that offer a network service which is principally that of a conduit — moving bits from here to there — may not restrict the content of the information they carry. The ability to restrict content, whether conducted by the government in the form of censorship, or by a private carrier for whatever reason, is not conducive to the free and open flow of information," he says.



So What's the Answer?

Now let's play Chinese menu, taking a few items from column A (Gore's NREN/Big Scientists bill) and column B (the Universalist approach).

A workable national network might include the following features:

- Built and managed by private enterprise.
- Federal start-up subsidies for colleges, universities, libraries and schools.
- First Amendment guarantees.
- Guaranteed interconnection to other data services offered by telephone companies and other locally regulated businesses.
- Guaranteed universal digital access for everyone who wants to connect.
- Fair rates and policies subject to regulatory review.

In short, we'd have a regulated public utility: precisely the system that the U.S. used over the past century to develop the best, and cheapest, public telephone system in the world.

The problem, as usual, is in how one defines the purpose of the national network. Laura Breeden, a network group manager at Bolt, Beranek and Newman (a private research and development company that was one of the original ARPAnet contractors), frames the issues this way:

"If you think of data networking as a public utility, then it seems important to regulate it in some of the same ways that other utilities are regulated, i.e. to make sure that basic services are provided to everyone and not withdrawn unreasonably.

"If you think of it as a strategic resource, important for insuring U.S. competitiveness and technological progress, then you put it where it can do the most good strategically.

"If you believe that it is important to education generally, then you put it at as many schools as possible.

"If you think data networking is some of all of these, you have to balance the trade-offs among them."

The National Network is a complex issue. It's safe to say that only a handful of representatives understand the issue in depth. A letter from you to your elected representatives asking for reasonable rates, guaranteed free-speech rights and access for local schools, libraries and homes might make a lot of difference. □

For more information concerning NREN, consult the following sources:

The WELL, Whole Earth's computer conferencing system, has extensive coverage of NREN/Internet issues in the Info, Telecommunications and Electronic Frontier Foundation conferences. Call 415/332-4335 (voice) or 415/332-6106 (modem) for more information on how to join the WELL. On the WELL you will find: Dave Hughes (dave@well.sf.ca.us), Steve Cisler (sac@well.sf.ca.us), Tom Valovic (tvacorn@well.sf.ca.us), Mitch Kapor (mkapor@well.sf.ca.us), and Roger Karraker (roger@well.sf.ca.us).

Mike Nelson, Senate Commerce Committee, U.S. Capitol, Washington, DC 20510; 202/224-9360.

Sen. Albert Gore, U.S. Senate, Washington, DC 20510. (Gore's office, or the Senate Commerce Committee, can send you a copy of Gore's article, "Networking the Future," published in the July 15, 1990 Outlook section of the *Washington Post*.

Coalition for the National Research and Education Network: Mike Roberts, Vice President/Networking, EDUCOM, 1112 16th Street NW, #600, Washington, DC 20036; Roberts@educom.edu

***Research & Education Networking*, a commercial publication devoted to developments related to NREN, is published nine times a year. Volume 1, Number 1 is eight pages long. Institutional rate is $59 annually; personal rate is $39. Available from Meckler, 11 Ferry Lane West, Westport, CT 06880; 203/226-6967; Fax 203/454-5840.**

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