Highways for Information

Obstacles litter the path toward a nationwide computer network for research and education

By IVARS PETERSON

In 1900, driving across the United States from coast to coast was a great challenge. Automobiles and horses shared the same dirt roads. There were few road maps or signs — and no guarantees that one road actually connected with another. There were no services. Drivers carried their own fuel and needed enough mechanical know-how to do their own repairs.

"That's very close to what computing is like today," says Robert E. Kahn, who developed ARPANET, a computer network linking researchers holding contracts with the Department of Defense. Kahn now heads the Corporation for National Research Initiatives in Washington, D.C., a group committed to the idea of building a nationwide, interstate highway system for information.

"Nowadays, you don't have to know very much to use a road," he says. In the same way, using a computer to communicate with colleagues, to share data, to send and receive pictures, and to draw upon library resources anywhere in the United States should be just as easy and convenient.

The present situation, however, is far from that ideal — even for networks devoted strictly to research. For example, the best way for a cardiologist at the Boston University Medical Center to review cardiac images with a colleague at the Mayo Clinic in Minnesota is to send the material by express mail or to fly there personally. Because no direct link capable of handling the images exists, the researcher can't use his or her office computer to send the information electronically. In contrast, scientists at the Massachusetts Institute of Technology can communicate with many research organizations throughout the world, but they must use the right one of more than a dozen computer networks to do so.

"These scenarios point up just two absurdities of the present situation in U.S. computer networking," comments C. Gordon Bell of the Ardent Computer Corp. in Sunnyvale, Calif., in the February IEEE SPECTRUM. "Existing networks not only lag behind the growing needs of the research community — they are too fragmented to develop unaided into a single, coherent system."

The troubled state of U.S. computer networks is one of the topics addressed in a report to Congress from the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which oversees the scientific endeavors of several federal agencies (SN: 3/12/88, p.172). The issue was also the focus of a recent meeting in Washington, D.C., sponsored by EDUCOM, a consortium based in Princeton, N.J., of more than 500 colleges and universities interested in information technology.

Some pieces of the national-network puzzle are already in place. Communications lines now connect six national supercomputer centers funded by the National Science Foundation (NSF). This network forms the backbone of NSFNET, which also has links with ARPANET and several NASA laboratories. By 1989, more than 200 universities will have access to the network.

In July, the network managers expect to increase data transmission rates from a horse-and-buggy rate of 56 kilobits per second to a respectable but hardly supersonic 1.5 megabits per second. Even at the faster rate, researchers would have trouble sending even a single picture without using up a large part of the line's capacity. That doesn't leave much room for other users interested in doing the same thing at the same time. Further increases in data transmission rates are planned.

"A lot has been accomplished," says Kenneth M. King, EDUCOM president. "But the task has just begun, and there are many problems."

The United States already has more than 100 computer networks, linking government laboratories, Defense Department operations, groups of universities, and researchers within specialized fields such as high-energy physics and computer science. Many large companies operate private networks carrying data to and from facilities all over the world.

However, connecting these diverse networks to a national "backbone" network is a complicated affair. Many times, different networks transfer information at different rates. Computers and associated equipment manufactured by different companies are often incompatible, although the computer industry is now attempting to set standards allowing all computers to exchange information readily.

"Our current networks grew up very quickly," says IBM's Ellen M. Hancock. "It's as if we merged the ivory tower with the Tower of Babel. These limitations are frustrating researchers across the country."

Even getting a message to the right place can be a problem because different networks have different rules, or protocols, for gaining access to the system and finding a particular person. For instance, a researcher using NSFNET, ARPANET and BITNET, which links many universities, must remember at least three different personal codes and passwords — and the appropriate "address" for a person receiving a message at the other end.

Sending a computer message should be as easy as making a long-distance telephone call. Many computer companies and network operators are gradually shifting to a standard known as the Open Systems Interconnection being developed by the International Standards Organization. Such moves could eventually lead to a single, easy-to-use system for making contact with any other computer user in the world.

Security poses another problem. Obviously, users of a network that encompasses both sensitive, defense-related transmissions and gossip about the latest mathematical proofs need assurance that information, whether stored in a computer or being transmitted, is secure and private. But as networks proliferate and expand, inevitable design flaws, loopholes and personal carelessness combine to create windows of vulnerability.

In one recent incident, someone in West Germany gained access to more than 30 computers belonging to U.S. military organizations and defense contractors. The intruder's route started with a telephone call from his computer in Hannover, West Germany, to a university computer in Bremen, which was linked to computers in the United States. That connection led to a computer at the Lawrence Berkeley (Calif.) Laboratory, which provided access to ARPANET and a second unclassified military network.

The intruder was able to sift through numerous computer files in search of information on the Strategic Defense Ini-

tiative. Although he did not gain access to any classified documents, U.S. military officials are afraid that such breaches of computer security could threaten national security.

Bringing libraries and other sources of bibliographic information and data into a national network also raises the dollars-and-cents issue of copyright and ownership. Some libraries experimenting with supplying textbook information and journal references are encountering opposition from publishers, who object to providing the information at no charge and fear the loss of sales. Such a system also makes it easier for computer users to incorporate information from numerous sources into a document without necessarily acknowledging the sources of information. The idea of a "national knowledge bank" that anyone can use is still far from reality.

Very little is known about how to manage the complex web of different computers, different users and different needs that a national network must somehow satisfy. Furthermore, reliability remains a problem even with present networks. "The system is down" is heard too often by too many researchers trying to get their work done. "Scientists want reliability," says Alison A. Brown, associate director of the Ohio supercomputer center in Columbus. "There's a big gap between what we need to do and what we actually do."

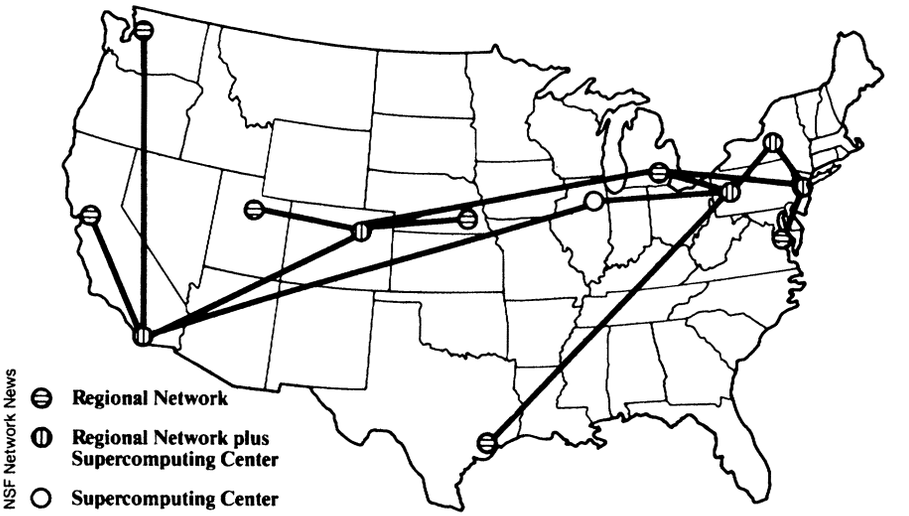
To be effective and useful, a national computer network — like today's interstate highway system — should be affordable, available to everyone, easy to share and simple to use. "The achievement of that vision has so far eluded us," Kahn says. "The problems are far more difficult than any one of us first imagined."

The need for a nationwide computer network for research is emerging as a priority on the national agenda. At the White House, the Office of Science and Technology Policy is pushing forward several FCCSET recommendations, and the National Academy of Sciences is presently studying the matter.

The FCCSET report states: "Present access to computer networks by researchers is dependent upon individual funding or location. There is unnecessary duplication in the links from various agencies to each campus. The development of improved networking facilities could greatly stimulate U.S. research and provide equitable access to resources."

Yet, despite an expressed interest, the response of both the federal government and Congress has been ambiguous. Still unanswered is the question of who should implement and manage a nationwide computer network.

Gordon Bell strongly urges that the federal government designate a lead agency to oversee networking. Funding for establishing and maintaining a national network would be focused in one place instead of being distributed within a variety of agency budgets. An early draft of the FCCSET report included a recommendation to that effect, but all references to the need for such a lead agency disappeared from the final version because participating agencies couldn't agree on who should be doing what.



Links between national supercomputer centers and regional networks form the backbone of NSFNET.

"Agency behavior is Byzantine," says Bell. "Each wants its own facility, no matter what the cost." Nevertheless, in January, NSF somewhat reluctantly volunteered to take on the role of lead agency for networking — although that role is not yet recognized in the federal budget and there is still some opposition from other agencies.

The centerpiece of NSF's program is NSFNET. Presently, NSFNET is run by Merit Inc. of Ann Arbor, Mich., a statewide research network connecting eight Michigan universities and one of the regional networks linked to NSFNET. Merit, working with IBM Corp. and MCI Communications Corp., has a five-year contract to manage NSFNET and boost the network's data transmission capability to 45 megabits per second — almost 1,000 times its present speed — in the early 1990s. NSF is providing $14 million over the next five years to fund development of this backbone network.

In a sense, NSFNET is stepping into the gap left by the dismantling of ARPANET, the first widely used national network for research. In the 1960s and '70s, ARPANET was "the glue that held the computer science community together," says Kahn. "People relied on it."

Now ARPANET is being dismantled because the Defense Department is not interested in running a "free" network for civilian scientists. Recent budget cuts already have forced ARPANET to abruptly cut off researchers in Texas and elsewhere to save money. In its place, officials at the Defense Advanced Research Projects Agency plan a new, more limited, experimental computer network aimed at pioneering novel networking technologies.

Central to the political debate over networking is the question of who should pay. The cost of implementing such a scheme could run hundreds of millions of dollars. Already, some regional and local networks are requiring users to pay a larger share of the cost of using network services. But researchers complain they lack sufficient funds to make the payments while meeting other research needs.

"To me," says Rep. Doug Walgren (D-Pa.), "it's a political problem, not a financial problem." Specific lobbying by the data-communications community in favor of networking has been minimal, he notes. "If Congress is properly approached, you will find it a full partner. The problem is that Congress has not been properly approached."

The trouble with computer networks is that, unlike computers, they are essentially invisible unless something goes wrong. That makes it harder to organize a broadly based constituency to promote the benefits of a nationwide computer network. Nevertheless, to an increasing number of computer-using researchers, the benefits are clear.

"Our institutions are becoming exquisitely sensitive to what happens nationally or internationally," says Hancock. The pace of research is so fast researchers often can't afford to wait for a journal article to be published or a paper to be presented at a meeting. "We need faster, more effective ways of sharing information," she says. "We are simply too dependent on each other not to have a national network."

"Everyone agrees that building the network is critical for this country," King says. "We need to educate Congress. We need a lead agency and an effective effort to get funding."

Says Kahn, "The elements are all there to make this infrastructure possible. We really can't afford to wait." □