Culture Shock on the Networks

An influx of new users and cultures could threaten the Internet's tradition of open information exchange, while commercialization is raising fears that pricing changes will squeeze e-mail and database browsing

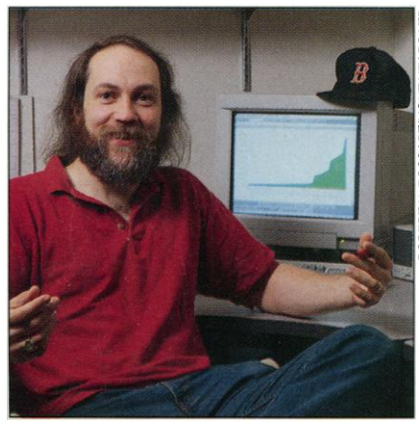
Back in 1990, when that vast, amorphous communications web known as the Internet was first being discovered by the world outside the laboratory, Frank Solensky had a vision of disaster.

What would happen if you just projected the Internet's exponential growth curve into the future, wondered Solensky, a software engineer at FTP Software in Andover, Massachusetts. When would the Internet hit the wall? When would construction on the "Information Superhighway" come to a crashing halt for the most absurd reason you could think of—that the net had simply run out of electronic addresses for any but the smallest new users?

Solensky's answer: March 1994.

In reality, of course, March 1994 has come and gone with no such apocalypse in sight—largely because Solensky's warning helped trigger some hurried, behind-the-scenes technical fixes, which have bought network engineers a few years' grace to work out a long-term solution. Nonetheless, with expansion roaring along at 10% to 20% per month and the worldwide population of users rising past 20 million, there's no more business as usual on the Internet. Like a quiet country village that's suddenly become a sprawling, brawling boom town, it's rapidly being transformed by an influx of new user groups and commercial interests. And among researchers who have come to depend on the Internet, reactions range from wistfulness—a sense of mourning for a half-mythical time of universal courtesy, technical competence, and open exchange of information—to outright alarm.

"People are bemoaning the loss of innocence," says Boston University sociologist Lee Sproull, who has been a pioneer in studying the folkways of the Internet. It isn't just the numbers, she says, but the fact that a great many of these newcomers are "outsiders"—whole new communities whose culture is not the culture of research. Some of these newcomers want to use the Internet for such previously verboten activities as commerce and electronic junk mail. And many, says Sproull, have "different views about information—for example, that you should charge for it."



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A voice of warning. Frank Solensky foresaw an Internet address crunch.

Computing in Science: Networks and Modeling

Just a few years ago, more computer power simply meant more processing speed and memory. Today the computer power available to scientists in all disciplines has been multiplied in many other ways as well, as the News Reports, Articles, and Perspectives in this special section show. Networks for sharing data, computational tools, and processor power are making everyone's computer a window into a wider world. Modeling techniques have deployed computer power in new ways, bringing it to areas it rarely touched before, such as immunology and cognitive science. And efficient new algorithms are multiplying the impact of each advance in raw processing speed. (Also see Editorial, p. 851.)

Internet veterans are also feeling uneasy about larger economic and political forces that have been converging on the Internet from the top at the same time as growth pressures it from the bottom, says Frederick Weingarten, executive director of the Computing Research Association, a trade association for computer science and engineering departments. In Washington, the Clinton-Gore Administration has put its weight behind the vision of a "National Information Infrastructure": a completely rebuilt telecommunications system in which telephones, cable television, and computer data transmissions would be integrated into a seamless, all-digital whole. No one knows how this information infrastructure would actually work in practice, says Weingarten. But with the major telephone and cable companies beginning to take a serious interest, he says, "you have this real culture clash coming up between the community as it exists now, where people just put stuff on the net, and what it inevitably has to be if it becomes part of the nation's infrastructure."

For example, Weingarten asks, what's the life expectancy of the culture of open information exchange if users have to pay a toll for every byte they send? And do high-level government officials and telecommunications executives even understand the implications of such decisions? "The ranchers are going to be coming in and putting up barbed wire," he says. "But we have to make sure that some public space is preserved. Otherwise, research, education, museums, and libraries could really get trampled." Sharpening the concerns about access are the proliferation of new resources available to researchers on the Internet, along with new tools for mining them (see, for example, the stories about software agents and on-line computer models of the immune system, pp. 882 and 886).

Range wars

The stage was set for the current boom in the early 1980s, when the National Science Foundation (NSF) decided to create a system of five national supercomputer centers to serve the research community—and to link the centers to all the nation's campuses via a long-distance network. The original idea, says NSF networking chief Stephen Wolff, was to allow researchers to gain access to the supercomputers without having to travel. "But in reality," he says, "the idea of using the network *only* to contact the supercomputer centers lasted about 15 microseconds. It was instantly apparent that the network could be a tool for general scientific communication"—a long-distance backbone linking regional research networks. But because of some key technical and organizational choices (see box on next page), the boom didn't stop with academia.

Instead, network veterans are confronting the current explosion of new Internet users and cultures—a development that, to put it mildly, is not universally popular. "The net has been taken over, occupied by squatters," one longtime user told *Science*.

It's an understandable reaction, says Boston University's Sproull. Today's Internet culture has its roots in the hacker culture of the 1960s, an exhilarating time when almost anything you did with a computer was new, and you couldn't wait to show it off. People freely passed around computer code, text

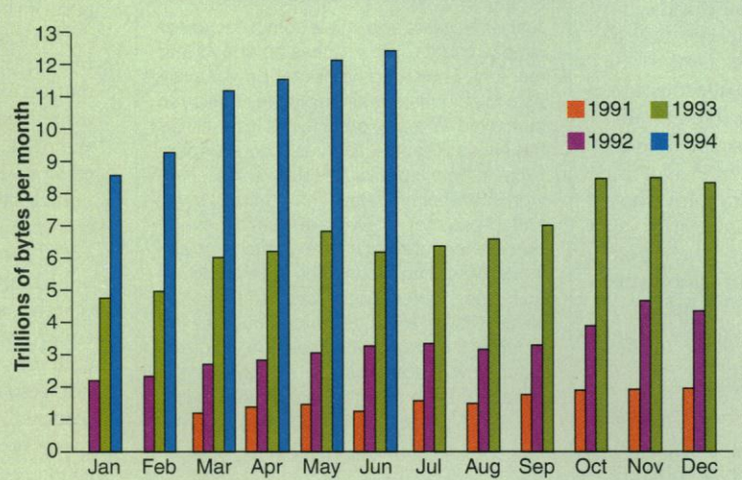
The Seeds of the Internet Boom

The Internet is rapidly becoming a foreign land to researchers, as new user groups flood in (see main text). And the irony is that what set this transformation in motion was an effort by the National Science Foundation (NSF) to advance research and education.

That effort dates to the early 1980s, when NSF decided to set up a network linking campuses around the country. In doing so, says NSF networking chief Stephen Wolff, who came to NSF in 1986, his predecessors made two critical decisions. The first was choosing to base the NSFnet on a well-established suite of communications standards known collectively as TCP/IP.

TCP/IP had been developed by the Defense Advanced Research Projects Agency (DARPA) starting in the 1970s as a lingua franca for networks, and had been implemented in 1983 on Arpanet, DARPA's network for computer-science departments. The idea was that, no matter how different a given pair of networks might be otherwise, they could always exchange messages as long as they both spoke TCP/IP and there was a data path connecting them. The resulting community of networks, which by that point included the Defense Department's satellite and radio networks as well as Arpanet and a number of others, was already being called the "Internet." And NSFnet joined this community in 1986 just when more and more colleges, universities, and research laboratories were beginning to wire themselves with local networks. NSF's choice of the TCP/IP protocol gave these local networks a standard to rally around, making them instantly compatible with NSFnet and the rest of the Internet.

The resulting growth rates were like nothing that anyone had imagined, says Wolff. Large numbers of researchers outside the computer science departments began to discover the addictive joys of electronic mail, remote file transfer, and data access in general. The upshot, says Wolff, was



Data in torrents. The burgeoning traffic on the Internet backbone.

SOURCE FOR GRAPHICS: THE INTERNET SOCIETY

files—everything. "It was a wonderfully romantic world in the best sense of the word," says Sproull. "People shared and were courteous—to the extent that within some parts of the network community, there was no such thing as a password. You could just log on to someone else's computer and read anything."

That commitment to information sharing survives today in people's willingness to post information on the Internet where anyone else can freely access it through browsers such as Mosaic. And the commitment to courtesy survives in the form of "netiquette": the unwritten rules that tell users not to waste other people's time with irrelevant electronic chatter—and especially, not to sully the network with self-serving advertisements and junk mail.

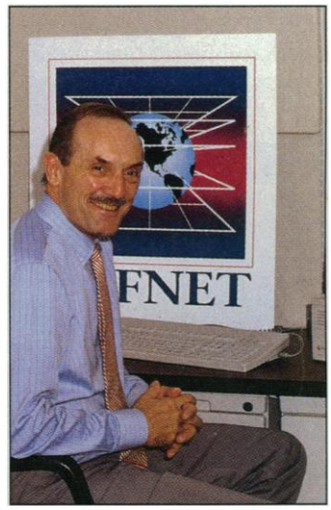
Now many users see those values as threatened. "Suddenly, with 20 million users on the Internet, there are people who want to use it to sell things," says University of Pennsylvania computer scientist David Farber, a leader in getting the NSF involved with networking in the first place. "So you're getting screams of agony: 'How dare you clutter my bandwidth with ads!'" By far the most dramatic incident to date has been the case of Canter and Siegel, a Phoenix, Arizona, law firm that advertised its "green card lottery" assistance last April on virtually all of the Internet's thousands of special-interest discussion groups, provoking a storm of outrage.

"That was the most egregious example," says Farber, "but there's lots of it. So there is remarkable pressure on the access providers to kick these people off. A lot of users think that's it's just wrong to use the Internet for commercial purposes—the same as people in a sleepy little town don't want a Wal-Mart going up on Main Street."

One answer might be something akin to zoning: reserving different portions of the Internet for different uses. In late 1993, for example, a consortium of Silicon Valley firms received a $6-million matching grant from the Clinton Administration's Technology Reinvestment Program to experiment with how the Internet can be used for business transactions. The result is CommerceNet, a separate enclave of the Internet for dues-paying members only, offering the higher levels of encryption, authentication, and data security needed when firms exchange sensitive documents such as bids and contracts.

However, even assuming that the relatively petty irritations of advertising and junk mail can be worked out, the advent of commerce on the network only underscores a larger question: Who, precisely, is going to control this new Internet?

Certainly not the NSF or any other part of the federal government. By later this year, in recognition of the fact that Internet backbone services are now being offered by several private firms, NSF plans to remove itself from the backbone operations entirely; Wolff's office is taking the $12 million it had spent every year on operating the backbone and giving it to the regional networks to buy long-distance service on the open market (*Science*, 21 May 1993, p. 1064). The changeover should be completed by 31 October, after which the foundation's only remaining backbone operations will be a much smaller, very high-speed system linking the supercomputer centers, along with four Network Access Points (NAPs) that will connect the various backbones much as highway interchanges connect the various interstates.

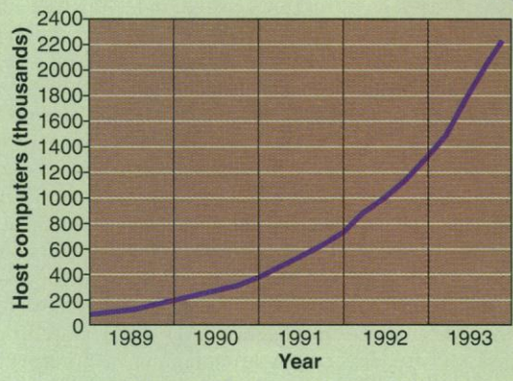


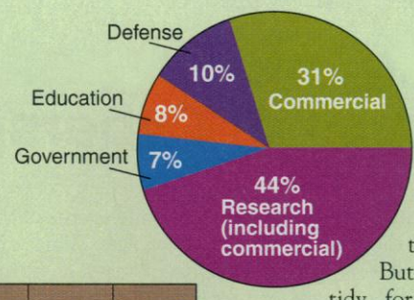
PREM SINGH

Getting out of the business. Stephen Wolff of the NSF is overseeing the agency's withdrawal from the Internet.

that by the beginning of the 1990s the NSFnet had expanded the Internet's constituency from its original base in computer science and engineering to the research community as a whole. And by that point the expansion was also beginning to embrace commercial users and the general public as well—in no small measure due to the foundation's second critical choice: its decision to decentralize the management of the NSFnet.

"The notion of trying to administer a 3000-node network from Washington—well, there wasn't that much hubris inside the Beltway," Wolff explains. "So we had to go to a hierarchical structure. We invited groups of universities, research laboratories, companies, and so forth to band together into consortia for regional networks." The idea was that NSF would be involved only at the highest level, by funding a high-capacity "backbone" linking the regional networks.





Anatomy of a boom. The Internet today is a diverse community of networks, many of them commercial *(top)*, embracing more than 2 million host computers.

The regional networks were duly formed with NSF seed money: SURAnet in the southeastern states, NYSERnet in New York State, BARRNet in the San Francisco Bay area, and many others, all operating as not-for-profit Internet access providers to the research community. But the scheme didn't stay this tidy for long. "We didn't have enough money to support the regionals forever," Wolff says. "So we told them, 'You guys will eventually have to go out and find other customers.' And they did. Out of necessity, we forced the regionals to become general-purpose network providers."

NYSERnet even went so far as to spin off a new commercial subsidiary, Performance Systems International (PSI) in Herndon, Virginia. And, at the same time, independent Internet access providers began springing up: Netcom, UUNet—dozens of them. "So by 1990," says Wolff, "we had all these young but extremely vigorous commercial operators who had no commitment to academia. They would just sell Internet access to business, industry, individuals, whoever would buy it." And the stage was set for the research network envisioned by the NSF to become something else entirely.

–M.M.W.

No more roaming?

At NSF headquarters, Wolff declares himself delighted with this outcome. The Internet has to become a commercial enterprise if it is going to survive, he maintains: "I want to make sure that the Internet can survive the vagaries of government financing." Others are not so sanguine, largely because they are concerned that the companies that own pieces of the Internet may be tempted to charge users individually for every bit of data they send.

Right now, after all, Internet users pay only for access to the network, not for the number of bits they send once they're on. For most users, in fact, the Internet is effectively "free," since their access charges are paid by their employers in much the same way telephone charges are. Users can send as many messages as they want, read and retrieve as many files as they want, and access as many remote databases as they want—anywhere in the world. "An important part of the Internet culture is a researcher sitting with a sandwich in one hand and a mouse in the other, browsing through Mosaic during lunch," says computer scientist William Scherlis of Carnegie-Mellon University.

But this is a part of Internet culture that could die very quickly if that researcher had to pay for every mouse click. "There is tremendous distrust and worry in the community about this all working out," says Scott Shenker of the Xerox Palo Alto Research Center (PARC), who feels that some sort of usage pricing is inevitable.

Right now, Shenker explains, the Internet offers one kind of "best-effort" service for everyone. That is, Internet messages will get there when they get there. The transmission protocols were designed so that the computer that's sending a message will automatically slow down when it detects congestion in the line and automatically resend any packets of data that get lost. That kind of system is fine for electronic mail and file transfer, says Shenker, because you don't really care (within reason) how long something takes to get where it's going.

Future Internet applications such as real-time, interactive video conferencing, however, will force the network to offer more than just best-effort service, says Shenker. Not only do these interactive applications demand huge data rates, he says—millions of bits per second—but they don't tolerate delays and late-arriving data packets the way e-mail can. "It's very hard for these applications to coexist with other kinds of traffic," he says. "They don't back off. They force everybody else to get out of their way."

To accommodate future audio and video applications while preserving the existing Internet culture, Shenker advocates something called the "Integrated Services Internet." He and his co-workers at PARC, the Massachusetts Institute of Technology, the University of Southern California, and USC's Information Sciences Institute have been working on such a design for some time now—as have many other research groups. The basic idea is for Internet providers to offer several grades of service. Some, such as those designed for video and audio applications, would try to guarantee minimal per-packet delays; the others would resemble the current best-effort service.

At the higher grades, interactive audio and video would be charged according to usage, much as the telephone companies charge by the minute for long-distance calling. But at the lowest level, e-mail and file transfer would continue to receive best-effort service and would continue to be charged at a flat rate.

So—is this how things will actually work out? Shenker doesn't pretend to know. "I don't think the network service providers will call me before they set prices," he says.

About the only thing that's certain is that the Internet will never again be what it was. "The Internet has to grow up and think of itself as part of the global telecommunications network," declares Wolff, "not just as a part of ARPA, or NSF, or academia. Sooner or later, every strength turns to a weakness. Turtles shed their shells. Snakes shed their skins. Sooner or later," he says, "the network has to change."

–M. Mitchell Waldrop