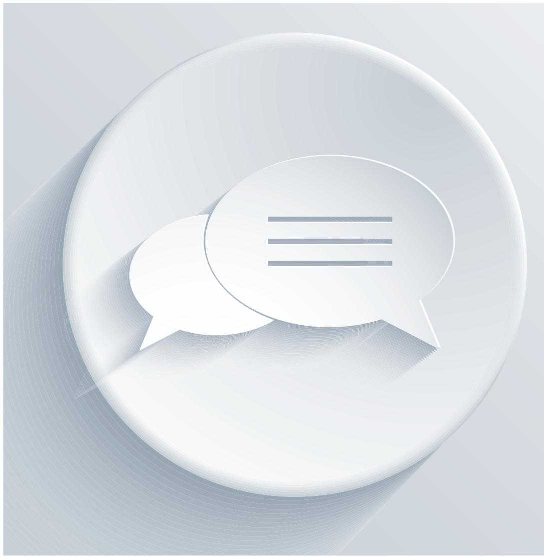

Doug Van Houweling: Building the NSFNet

Charles Severance, *University of Michigan*

Doug Van Houweling describes how the NSFNet went from connecting a few supercomputers to becoming "the Internet."

The Arpanet connected ARPA's computers to researchers during the 1970s and 1980s. In the mid-1980s, the National Science Foundation (NSF) decided to deploy shared supercomputing resources at several universities around the country. It connected those centers with a TCP/IP network that would eventually become known as the NSFNet and later evolve to be the public Internet.

Doug Van Houweling was the University of Michigan's CIO back in the 1980s and was instrumental in bringing together several partners to craft the grant that greatly broadened the NSFNet—he was also involved in guiding the project through 1995. Visit www.computer.org/computingconversations to view our discussion.

STARTING WITH SUPERCOMPUTERS

In the mid-1980s, the NSF issued a request for proposals from universities to host supercomputer centers, and the University of Michigan was one of many that wanted in. However, the inclusion of the Japanese-built IBM-370–compatible computer in its proposal was a risk because it turned out that the US government wasn't inclined to spend scarce research dollars purchasing major computing equipment from a company outside the US:

> I was visiting the NSF and had gotten to know Eric Bloch, its director at the time, so we talked about Michigan's proposal. It was clear to me from our conversation that there was no way that the Michigan proposal would be funded. I told Eric that it might be even better for Michigan if we could run the network that would connect all the centers together. At the time, I was chairman of the board at Merit, Michigan's statewide network. Over the years, in parallel with the packet-switching protocol developments that had been involved in the Arpanet, Merit had developed its own packet-switching network, using its own communications processors built on Digital Equipment Corporation systems.

Although Merit wasn't deeply involved in the early Arpanet project, it had extensive experience in packet-switched networks and helped to operate the 56-Kbit first-generation TCP/IP-based NSFNet backbone that initially connected the five supercomputer centers starting in 1986.

NEW PARTNERS

The team at Merit wanted to keep the budget for the project under \$15 million to make sure the proposal was financially attractive to the NSF:

> As we thought about how we would create this proposal, we realized very rapidly that \$15 million would only fund a 56-Kbit network, which we already knew would be insufficient. So we immediately started thinking about how we could expand the envelope for the proposal.

Merit started looking for partners who would be willing to contribute hardware, software, services, and money to expand the project's scope while staying within budget. Van Houweling had a friend named Al Weis who worked at IBM Research:

> I called Al and described this as a great opportunity, but IBM wasn't going to be successful here, so I needed his help. Al rallied some folks at IBM Research—people who were actually working on TCP/IP protocols. We had another meeting, after which some of us admitted that some people in IBM do know something about TCP/IP, and yes, they could be partners. We got a tentative agreement from IBM that it would contribute the hardware and the software to create the network's routing structure.

Continuing to work through his IBM contacts, Van Houweling was introduced to a former IBM employee named Dick Liebhaber, who was then the CTO and chief network operations officer for MCI. Together, they approached MCI to donate the communications lines for the project:

> At that time, MCI was a fledgling organization that some people had described as a law office trying to create an environment that could offer telecommunications up against AT&T's lobbying efforts. It had just succeeded in reaching that goal and had started establishing facilities across the US. Dick thought being part of the NSFNet proposal was an opportunity to move MCI into the big time.

With IBM providing the hardware and software and MCI providing the connectivity, Van Houweling also got a commitment of $1 million per year from the State of Michigan:

> We submitted a proposal to the NSF for $14.7 million—we knew the budget was $15 million. But by including all this in-kind activity, it was actually more like a $55 million proposal. And it wasn't designed to be 56 Kbits—we could start at T1 or 1.5 Mbits with planned upgrades over the period of the network's life.

A UNIQUE PROPOSAL

With an unlikely set of partners, and large in-kind contributions, the University of Michigan/Merit Network offering was quite different from the rest of the proposals to build the NSFNet:

> We subsequently learned that our proposal was received with considerable skepticism by the reviewers at the NSF because IBM was thought of as the enemy of the Internet because it was so focused on its own proprietary protocols. The reviewers really wondered about our technical ability to pull this off. The first review was conducted without reference to the actual funding pattern, so when the wraps came off about the amount of resources being committed by our partners, we went to the top of the list.

But once the proposal was awarded, Merit, IBM, and MCI needed to deliver on their promises:

> When we started the network, we had T1 circuits, but there were no cards for computers that would go at 1.5 Mbits, so we had to build our initial routers with 448-Kbit cards, subdivide the T1 circuits into three 448-Kbit circuits, and build a mesh network among all the routers. It took about a year for IBM to build prototype cards that would go at 1.5 Mbits. When we the put the 1.5-Mbit cards into our test network, they worked just fine, but when we put them into the production network, it started failing. After a lot of testing, we discovered that the folks who had built the T1 hardware for MCI had planned on using certain bit patterns for diagnosis on the network and had never anticipated someone using the full 1.5 Mbits as a single channel.

Once the NSFNet was upgraded to 45-Mbit communication links, it had enough bandwidth to handle traffic growth for the life of the project.

MOVING ON UP

Over the first few years of the NSFNet, these technical details got worked out, and the network started to take off as regional networks formed and campuses were connected. By 1990, the T1 circuits were filling up, so it was time to move to DS3 (45-Mbit) connections. This would require entirely new router software and hardware technologies to be developed:

> Merit was still the principle investigator on the grant, but it subcontracted the development of this new 45-Mbit network to Advanced Network Services [ANS], another not-for-profit organization we created and headquartered in Armonk, New York. IBM, MCI, and Nortel each contributed $3 million to the founding of this new organization, so it had the staff and facilities to do the innovation necessary to get us up to 45 Mbits.

Once the NSFNet was upgraded to 45-Mbit communication links, it had enough bandwidth to handle traffic growth for the life of the project. But as the 1990s progressed, there was increasing pressure to move management and operation of the "national Internet" to the private sector:

> The NSFNet was decommissioned in 1995 when Congress decided that the federal government shouldn't be in the business of supporting something that by that time, in its view, should have been a commercial facility. I

> won't ever forget sitting in a House hearing room in the Capitol next to Mitch Kapor and the CEO of a small Internet startup who were complaining that it was inappropriate for the NSFNet to be funded by the NSF because the startup could provide a national backbone as a commercial service. Meanwhile, the commercial backbone networks were using the NSFNet as their backup to carry traffic when their much less reliable networks failed.

As Merit, MCI, and IBM transitioned away from daily operations and maintenance, they were still in possession of the world's fastest and most reliable router technologies. MCI used its expertise and reputation to quickly become a successful national backbone network provider. IBM had to decide if it wanted to evolve its market-leading routing hardware and software into a commercial product:

> In a classic "innovator's dilemma" moment, IBM, which was the leader in high-speed routing technology for Internet backbones at that time, decided to kill all the work it had done in developing these routers because it threatened the company's proprietary network efforts. Canceling the router effort within IBM was almost certainly responsible for the fact that Cisco became the dominant router provider in the US rather than IBM.

Looking back, it's easy to imagine that our current networking environment might have been quite different if the first research-centered national TCP/IP backbone had been limited to a $15 million budget between 1985 and 1990. But when the NSFNet award was given to an unlikely group of collaborators, we ended up with a national network that was fast enough for nearly a decade to function as a platform for innovations such as Gopher and the World Wide Web, leading us to the shared, free, open, and nondiscriminatory global network infrastructure that we enjoy today. C

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