

Cisco Helps Dartmouth Lead Ivy League into Wireless Age



Dartmouth College

- Located in Hanover, N.H., Dartmouth is the nation's ninth-oldest college
- Student body (Fall 2002):
 - 4,079 undergraduates
 - 1,514 graduates
 - 327 in the Medical School
 - 162 in the Thayer College of Engineering.
 - 467 in the Tuck School of business.
 - 380 full-time faculty in 39 academic departments and programs.
- Operating budget (2002-2003): US\$511.4 million

Dartmouth College has deployed a wireless computing network that ensures access to the campus network and the Internet from virtually anywhere on campus. The wireless local area network (WLAN) was built two years ago using Cisco® Aironet® 350 Series access points. Newer Cisco Aironet 1200 Series access points, which support IEEE 802.11 a, b, and g standards, will gradually replace them.

Background

Dartmouth College is the ninth oldest college in the United States and a member of the prestigious Ivy League of U.S. colleges and universities. Located in Hanover, New Hampshire, Dartmouth is a private, four-year coeducational undergraduate institution offering 18 undergraduate programs in the arts and sciences and graduate and doctoral degrees through its schools of business, engineering, and medicine.

Dartmouth has a long history of innovation and leadership in research and teaching. Its Amos Tuck School of Business Administration was the first graduate school of management in the world; the Thayer School of Engineering was the first of its kind in the U.S.; and the college's medical school was the nation's fourth.

Dartmouth is also a pace-setter in computing: The entire 200-acre main campus has been wired since 1985, providing access for students, faculty, and staff to the campus LAN, which links all residence hall rooms, academic buildings, administrative offices, and mainframe computers on and off campus. Nearly all undergraduates and most graduate students live in a networked campus building.

Challenge

Access to the Internet was limited to the number of wired connections available on campus. But both faculty and staff required increased mobility on the campus network. "Our Ethernet system has been a substantial improvement over what had been available to the campus community before, but it wasn't long before we knew we had to upgrade to the next level," says Lawrence M. Levine, the college's director of computing. "Today's society is highly mobile, with people working from anywhere and whenever they want to. It's not a nine-to-five world anymore. People are constantly multitasking—especially students. You see them walking on campus doing homework or research, communicating, or accessing information. Our vision was to answer the needs of this mobile community by providing wireless access throughout the campus."

“A classroom can really be anywhere. As long as it’s not 20 degrees below zero, students and faculty can congregate in any of our green areas. Since most classes at Dartmouth are small to begin with, studying or conducting classes outdoors is already a popular choice. With wireless added, the teaching can be supplemented by Internet access no matter where the class convenes.”

—Brad Noblet, Dartmouth’s director of technical services

Administrators decided that a campus-wide wireless overlay would meet the mobility requirements necessary to support networking in hard-to-reach or temporary locations, including outdoor areas, which probably would otherwise have been left out altogether. With campus-wide access, academic pursuits could take place virtually everywhere—in classrooms and other academic buildings, in dormitories, or even outside.

“A classroom can really be anywhere,” explains Brad Noblet, Dartmouth’s director of technical services. “As long as it’s not 20 degrees below zero, students and faculty can congregate in any of our green areas. Since most classes at Dartmouth are small to begin with, studying or conducting classes outdoors is already a popular choice. With wireless added, the teaching can be supplemented by Internet access no matter where the class convenes,” he says.

Solution

Dartmouth settled on Cisco Aironet technology for its wireless network in part because of the college’s positive experience with other Cisco products, including Cisco routers for wide-area network (WAN) routing and Cisco Ethernet switches for the existing wired network. “Cisco has been the best vendor technically, and the company is also likely to promptly follow—and help shape—emerging standards,” Levine says.

The Dartmouth architecture includes Cisco Catalyst® 3550 Intelligent Ethernet switches and Cisco Catalyst 6500 switches, both of which are designed to help maximize bandwidth management. “Better bandwidth management is a strong feature for us,” Noblet says. “We intend to take maximum advantage of the capabilities these switch families provide.”

Intelligent switching increases bandwidth availability at the network edge, where users are connected to the network. This is in contrast to previous practices, where the network intelligence that controlled

data traffic was limited to the core or backbone. The advent of small and medium-sized networks has generated an increased need for high availability, advanced quality of service (QoS)—also featured in the Catalyst 6500 Series— and improved security at the network edge. Extending network intelligence to the edge makes it possible for data traffic to be classified at the source, thus permitting prioritization of both upstream and downstream traffic to minimize congestion. In addition, it enables network administrators to establish policies on a per-user basis, freeing up router processing power.

The Cisco Catalyst 3550 Series switches also include security access control lists (ACLs), which protect networks from internal and external threats by authenticating users, restricting access, and isolating traffic en route to its destination. Cisco Cluster Management Suite (CMS) software, embedded in both 6500 and 3550 series switches, simplifies the time-consuming task of deploying intelligent services.

At present, Dartmouth depends on Cisco PIX® firewalls for security, which support up to 500,000 simultaneous connections and nearly 1.7 Gbps aggregate throughput. “We are presently evaluating additional security options but are guided by the proviso that access to the wireless network be as trouble-free and simple as possible for our campus community,” says Levine. “We don’t want to discourage anyone from using the network by requiring them to log in numerous times per hour.”

The college also is deploying a voice-over Internet Protocol (VoIP) communication system, based on Cisco technology. On-campus users will be able to use Cisco IP SoftPhone systems from their laptops, Cisco 7920 Series wireless IP phones, and Cisco CallManager—the Cisco IOS® Software-based call-processing program. In addition, Dartmouth has deployed a Cisco virtual private network (VPN) 3030 Series concentrator. VPNs are an alternative WAN infrastructure and can replace or augment existing private networks using leased-line or Frame Relay/ATM networks.

“ Many people go on the road with their laptops and Cisco SoftPhones, and our system allows them to easily connect to the people with whom they need to have contact. For example, I can go wherever I want and through whatever Internet connection I plug into, I can run my SoftPhone program on my laptop to get a dial tone as if I were sitting in my office. This also is possible wirelessly anywhere on campus. It is a very robust system.”

—Lawrence M. Levine, the college director of computing

“The goal,” explains Levine, “is to deliver the virtual office, classroom, and library outside of Dartmouth so that, via the VPN connection, users have access to local resources and to a Dartmouth dial tone.

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At the core of the wireless solution are the Cisco Aironet access points. The original installation included more than 400 Cisco Aironet 350 Series access points. There are now more than 560 Cisco points installed on campus—a number that will double over the next 12 to 18 months. “The entire campus is covered, but higher demands on bandwidth will mandate greater access point density,” Noblet says.

With that in mind, Dartmouth is switching all additional access points to the Cisco Aironet 1200 Series. Over time, all of the existing Cisco Aironet 350 Series access points will be replaced with Aironet 1200 Series.

Cisco Aironet 1200 Series access points support the longstanding IEEE 802.11b standard as well as the new IEEE 802.11a, and offer support for IEEE 802.11g standards. Because the IEEE 802.11b has an 11-Mbps data rate and operates in an unlicensed portion of the 2.4-GHz radio frequency spectrum, it offers a relatively narrow band and provides only three operating channels. With the addition of support for the new IEEE 802.11a and 802.11g standards, the Aironet 1200 Series helps create a network that is both scaleable and cost-effective.

In addition, the new 802.11a standard, which has a data rate of up to 54 Mbps, offers greatly enhanced performance and eight distinct channels for enhanced scalability. Although this standard is not interoperable with 802.11b devices, many multimode .11g/.11a clients have been introduced, with .11a providing interference immunity from devices that operate in the 2.4-GHz band, such as cordless phones, Bluetooth devices, microwave ovens, and hand-held barcode scanners.

The IEEE 802.11g standard provides backward compatibility with IEEE 802.11b equipment, preserving the college’s investment in its existing WLAN infrastructure. However, because 802.11g is limited to the same three channels as 802.11b, scalability may become a factor as WLAN user density increases.

The Cisco Aironet 1200 Series access point is capable of single-band or dual-band operation to simultaneously accommodate one radio for 802.11b or future 802.11g clients and another for high-speed 802.11a clients. The Cisco Aironet 1200 Series can be upgraded in the field—for instance, customers can order it with the 802.11b radio and easily add or swap out radios to the new standards as their application and bandwidth requirements evolve. Many organizations, to take full advantage of these new capabilities, are structuring their WLANs deployments to enable them to easily migrate from single band to dual- or tri-band WLAN infrastructures

“We certainly anticipate a significant protocol change in the near future, which will require the current infrastructure to increase bandwidth,” Noblet says. “We are on the ‘b’ standard now, and with the Cisco Aironet 1200s, we can take advantage of the new ‘a’ and ‘g’ standards.”



“Our overarching strategy has been to build a converged network, because we have a vision of delivering what is now in separate networks—video, voice and data—through one network.” The college is also experimenting with upgrading its cable TV system to run over the IP network. “Students will be able to watch TV on one window, check e-mail on another, and do homework on a third,” Noblet explains. “We want to converge media to deliver that content over a common infrastructure.” In addition to being convenient for students, this convergence will provide substantial savings to the college. Finally, he says, a converged network allows the college to prepare for new software applications that require the additional bandwidth available in the new standards.

“This is one of the reasons we are looking at ‘a’ and ‘g’ [standards],” Noblet says. “The ‘g’ standard won’t give us enough capacity for video, but new clients will be tri-band, and with laptops you can get a card that operates on any of the three standards. Therefore, based on your application, you can select whichever network you want to be connected to. As for the ‘b’ standard, we will designate it for Web surfing and VoIP. Cisco products make it possible for us to pursue this ambitious but very do-able vision,” he says.

Results

The WLAN is available to approximately 4,000 undergraduates, 1,200 graduate students, 1,000 faculty members, and more than 3,000 staff members. According to Noblet’s research, the WLAN is regularly used by approximately 2,200 simultaneous users. Figures compiled in September 2003 indicate that the number of total users per day exceeds 3,500.

Noblet and Dartmouth Computer Science Professor David Kotz also submitted a proposal to chart the use of VoIP, which was recently awarded by the Cisco University Research Program.

The entire network is reliant on an access system that incorporates unlimited mobility, says Kotz. “With the new system, we have the ability to access information

from unwired places outdoors, in dining halls, in informal study spaces, and at classroom seats. Even the athletic fields are covered.”

“We’ve demonstrated that wireless is the best way to provide Web access to all students in a cost-effective way,” said Edmond Cooley, director of information technology at the college’s Thayer School of Engineering. “One of the biggest benefits we see is people sitting and working together where they can easily get network access. This means there are fewer students competing for the handful of hard-wired computers. Wireless is fast becoming a viable and important tool in the education process.”

Dartmouth has identified a variety of additional academic applications for the wireless network, including:

- “Smart classrooms,” where professors can broadcast presentation materials to each student’s laptop in class. Classrooms of any size—even ad hoc arrangements—can be “smart,” precluding the need for installed fixed-projection equipment. Professors also can respond to individual and group questions posed electronically.
- Support for researchers, which will enable them to collect and analyze data from remote locations and receive instant feedback for collection parameters.
- The ability to allow students to monitor class or laboratory projects from anywhere on campus, checking computer system status, observing biological or chemical equipment, or monitoring other instruments.
- Shared calendars that instantly inform students of changes in class meetings or schedules.

“These new applications only hint at what is possible with the wireless network,” says Kotz. “Students and faculty may find new ways of collaborating on projects using a shared virtual ‘whiteboard.’ New and dynamic Web pages will take shape to display material relevant to a wireless location. I confidently anticipate that students and faculty will develop applications we haven’t even dreamed of yet.” Already, students and

faculty from the Department of Computer Science, the Thayer School of Engineering, and other departments are working on creating new applications, he adds.

“Dartmouth was the first in the Ivy League to implement a campus-wide wireless network, which was designed to allow students and faculty alike to work on new applications and pursue new and exciting academic directions,” says Levine. “They clearly are taking advantage of it.”

Psychological and Brain Science Professor Chris Jernstedt, whose field of research is the ways people learn, incorporates wireless into classroom activities. Using Handspring™ handhelds and software written at Dartmouth’s Center for Educational Outcomes, he is able to query his students via their wireless handhelds while at the same time delivering his lecture. The students can interact via their handhelds to the data he provides, replying to queries he poses and providing Jernstedt with instant feedback that enables him to reinforce points or move in new directions, based on each individual’s response. Student responses can be displayed on a projection screen so that the class can follow its own progress. Outside class, students can learn in smaller cooperative groups using the same handhelds or laptops.

“This format engages students much more actively than if they were merely sitting in a classroom taking notes,” he says. “The system has changed how I teach and how my students learn, enabling us to tap the true power of the human brain.”

Next Steps

With the entire campus covered by wireless, Dartmouth officials are looking next to extend the WLAN outward into the local community, particularly into nearby residential areas. The campus is in a very rural area with no cable modem and limited DSL, and extension of the WLAN would be a cooperative effort, with Dartmouth supporting the development of an off-campus infrastructure.

Already, the college has fostered limited extension of the network in the area next to campus through a small student-managed company called Greenwave Wireless. This initiative provides members of the Dartmouth faculty, staff, and student body with high-speed, low-cost wireless connections from their homes to the Internet and the campus LAN. Cisco Aironet access points support Greenwave Wireless.



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