Increasingly, higher education’s thinking about networks extends beyond its physical borders. Commodity Internet access is now pervasive for access to myriad campus services such as student services portals, course management systems, and library resources. And colleges and universities are connecting to a growing infrastructure of state, regional, and national research and education networks that offer a range of services—from production networks to a cutting-edge research networking environment. This chapter looks at how students, faculty, and staff access institutional resources from off campus and how they connect to resources external to campus.

The Commodity Internet

Today, students, faculty, researchers, and staff all rely on the commodity Internet for many of their campus activities. For example, Eastern Michigan University’s Rocky Jenkins, director of network and systems services, says their CIO “has given us a guiding principle as we select and implement new technologies: Deliver everything via a Web browser to enable our users to access any resource just as easily from a hotel room in Seattle as from their campus office.” As Figure 5-1 illustrates, our responding institutions make substantial bandwidth available from the commodity Internet. Bandwidth ranging from 4.6 Mbps to 89 Mbps accounts for 60.6 percent of institutions. And almost a tenth (9.9 percent) of our respondents tell us they provide 300 Mbps or more bandwidth. Of these institutions, 32 out of 51 are doctoral universities.

Key Findings

- Higher education institutions and organizations are actively building a private infrastructure of state, regional, and national research and education networks. Approximately 26,000 segment-miles of dark fiber have been acquired as part of these initiatives.
- Doctoral institutions are most likely to connect to all of these national research and education networks. Master’s, baccalaureate, and associate’s institutions are most likely to connect to a state educational and research network.
- Institutions are moving away from providing remote access via internally managed modem pools. Doctoral and large institutions are most likely to still use these campus modem pools.
- Although most institutions connect to the commodity Internet via leased circuits to an Internet service provider (ISP), there is a trend to use private fiber connections or to co-locate network facilities, especially among doctoral institutions.
- Institutions widely use virtual private networks to provide remote access, especially to staff and faculty.
Not surprisingly, our data show a clear relationship between the size of the campus network and the availability of Internet bandwidth (see Figure 5-2). Most very small networks of 1,000 or fewer devices (46.6 percent) make 4.5 Mbps or less bandwidth available from the commodity Internet, while most very large networks of more than 20,000 devices make 300 Mbps or more available (41.3 percent).

We also asked how institutions physically connect to the Internet. Figure 5-3 shows that most use leased circuits from ISP locations (73.3 percent). However, there is a trend to co-locate network facilities at the ISP (11.6 percent), especially among doctoral institutions (25.4 percent). There is an even stronger trend to connect to the Internet through a private fiber connection (28.4 percent of respondents). Again, doctoral institutions are more likely to have private fiber connections (40.0 percent). Canadian institutions surveyed also show a preference for private fiber connections, with over half (53.3 percent) connecting to the Internet in this way.

**Remote Access**

Today, most institutions and corporations must support remote access for users who...
are becoming ever more mobile—working extended hours from home and communicating from other cities. In higher education’s fluid environment, where students and faculty often live and spend much time off campus, this is especially important. Overall, 77.4 percent of institutions do provide remote network access to their campus backbone, with doctoral institutions most likely to do so (92.3 percent) and associate’s institutions least likely to do so (65.9 percent). However, Figure 5-4 shows that the clearest trend is based on institution size. Large institutions most often provide remote access; in fact, only three institutions with more than 15,000 students didn’t provide remote access to their users. We found no significant differences between public and private or between Canadian and U.S. colleges and universities.

Figure 5-5 illustrates that institutions most commonly provide remote access via an internally managed modem pool (58.0 percent). Fewer than one-tenth of institutions use other methods, such as outsourcing a modem pool (6.6 percent), obtaining discounts with ISP accounts (9.7 percent), or subsidizing ISPs (8.9 percent). Doctoral institutions are more likely to have an internally managed modem pool (73.8 percent). Canadian institutions have a different profile, with only 50.0 percent having an internally managed modem pool. Instead, they more often outsource their modem pool (23.3 percent). Size also plays a role in an institution’s choice to arrange ISP discounts: while only 5.0 percent of institutions with an enrollment of 4,000 or less provide ISP discounts, 18.1 percent of institutions with enrollments over 15,000 do so. It makes sense that larger institutions can better leverage their populations to negotiate discounts.

Figure 5-3.
Physical Connection to the Commodity Internet (Multiple Responses Allowed)

Figure 5-4.
Remote Access Provision, by Institution Size (N = 508)
In light of the rapid rise of dial-up providers and increasing availability of broadband, many institutions are phasing out their internal modem pools. As Colorado State University’s Scott Baily, associate director for networking, observes, “Less than 5 percent of our students subscribe to the university’s modem service. Though modem pool usage has steadily declined over the past several years, CSU feels strongly about providing this service. Many faculty, staff, and retirees like it and feel it is a bargain. That group makes up two-thirds of the current subscriber base. As long as the modem pool satisfies a need and is self-sustaining, we’ll continue to support it.”

This trend away from internally managed modem pools is corroborated by the ECAR study on security, which found that in mid-2003, 76.2 percent of institutions were using a campus modem pool. This 2004 study finds that only 58.1 percent are doing so. And recently, from a student perspective, the ECAR 2004 study on students and information technology reported that only 8.6 percent of seniors and 14.7 percent of freshmen used a university-operated dial-up modem service. Brian D. Voss of Indiana University sums up by saying that “modem pools are dinosaurs” and further recommends “getting out of the biz of being an ISP.”

Institutions are choosing to implement virtual private networks (VPNs) as part of providing remote access (see Figure 5-6). “VPNs do a couple of things for us,” explains Spero Bowman, CIO/associate vice president for academic resources and planning, California State University at Northridge (CSUN). “They provide us with an additional security layer, as well as give us a little more flexibility. We also provide a modem pool. Home computers, however, can be an enormous source of infections, which needs to be addressed.”

Almost three-fourths of institutions provide VPN capability to staff (70.1 percent),
more than half of our institutions provide this service to faculty (55.8 percent), and more than one-quarter of institutions provide this service to students (28.0 percent). Half of institutions (49.5 percent) provide access to both faculty and staff, and more than one-fourth (26.7 percent) of respondents said they provide VPNs to all of these user groups—staff, faculty, and students. We found a relationship between institution size and VPN provision: larger institutions are more likely to make VPNs available to campus constituents. Canadian institutions mirrored U.S. institutions in VPN deployment.

**Connections to External Networks**

Our interviewees told us there is currently much effort and energy devoted to creating and/or joining external educational and research networks. Figure 5-7 shows the major types of external networks and the extent to which institutions are participating in these networks. We find that 39.3 percent of institutions connect to a university system-wide network. State educational and research networks are also quite popular, with 43.0 percent of respondents participating. Regional gigaPOPs connect 24.8 percent of our responding institutions.

The choices institutions make as to which external networks they join relates strongly to their Carnegie class. Doctoral institutions are most highly connected to all types of the higher education networks shown in Figure 5-8. State research and educational networks are the most common choice among master’s, baccalaureate, and associate’s institutions.
Doctoral institutions clearly have the most connectivity to external research and education networks, as research needs demand access to external resources and are increasingly multi-institutional. For example, not long after her appointment as Hampton University’s first CIO, Debra S. White, a former IBM executive, found that in addition to managing a campus IT network upgrade, she had to contend with demanding scientists conducting nationally acclaimed and highly advanced research involving elements that far eclipse typical administrative and educational needs. Indeed, a U.S. Department of Energy study found that the network requirements for scientists in high-energy physics, astrophysics, fusion energy, climatology, bioinformatics, and other data-intensive fields will reach the terabit-per-second range within the next decade.

External Networks: Putting the Pieces Together

Completion of a higher education national research and education infrastructure requires that all these individual efforts come together—state, regional, and national networks. At the national level, Internet2 created the Abilene network, operational since 1998, to address higher education’s high-performance needs not met by the commodity Internet. It now has more than 300 Internet2 university, corporate, and affiliate member institutions and considers its mission to not only provide a leading-edge national network and enable revolutionary applications, but also to ensure the transfer of new network services and applications to the broader Internet community.

The National LambdaRail (NLR) nationwide infrastructure, very recently conceived, is being constructed by installing optical equipment on fiber acquired from telecommunications companies. NLR’s goal is to support a set of multiple, distinct, experimental and production networks specifically for the U.S. research and education community. Tom West, president of NLR says that “NLR is a natural evolutionary step in meeting high performance research needs. It somewhat mirrors the behavior of the research and education community where physicists want to communicate with physicists, astronomers with astronomers, etc. If they have an option to have their own dedicated network for a project or the discipline, they will.”

At the state and regional level, 34 research and education networks are now in place or being implemented. Most of these are moving toward a model of facility-based networking built with owned assets, called regional optical networks (RONs). These regional networks give their constituents connectivity to external networks, and their constituencies are growing. Jim Dolgonas, president and COO of the Corporation of Education Network Initiatives in California (CENIC), describes their evolution toward supporting the larger education and research community. “CENIC has gone way past its original vision as a network just for research institutions to including K–12 (currently about 85 percent of school districts and 80 percent of schools are connected), the California State University (CSU) system, and all of the community colleges. There are gigantic economies of scale. Economically it just makes sense to operate a statewide network.”

Internet2’s Doug Van Houweling considers working with state and regional initiatives one of Internet2’s most challenging roles—to share vision and ensure a common architecture and proper integration. “It all needs to come together as a higher education network. For example, Louisiana does not benefit from just Louisiana connectivity. They need connectivity to the U.S. and the world—the local must be incorporated into the national. The investments are regional, but the benefits go far beyond the region.” NLR President Tom West is also a strong advocate of the research
and education network infrastructure helping to reach all citizens. He says, “I believe that the research and education community has a stewardship role to the larger community. We must provide connectivity to every location in the country.”

As these efforts build the educational infrastructure outward into the community, metropolitan wireless technology is now helping small towns reach these networks. Mark Luker, EDUCAUSE, reflects that “the missing link is that last mile, where cities and rural areas are not fully wired, where the telcos won’t go. Here, the huge breakthrough is wireless. Small towns are starting to install wireless—putting antennas on grain silos and water towers. This is happening on a wide scale, with hundreds of small towns across the country. They can network the whole town in one day for very little money, and that brings high speed access to them all at once.”

These private initiatives have benefited from the market conditions in the telecommunications sector by acquiring unused (dark) fiber at affordable prices. Ed Gubbins, in a Telephony article, says that “The low price of distressed assets, combined with new federal funds from the National Science Foundation, has tempted a number of states and universities to build their own fiber networks.” Several telecommunications providers—for example, Level 3 and Qwest Communications—have sold large amounts of dark fiber to research and education groups, and AT&T donated 6,000 miles of fiber plus associated optical equipment to the Southeastern Universities Research Association (SURA). An Internet2 presentation in fall 2004 summarized dark-fiber acquisitions by U.S. research and education groups (Table 5-1), and Internet2 considers this a conservative estimate.

Our study findings show that about one-third (34.1 percent) of our respondents have acquired dark fiber, with more than one-third of these planning to acquire more. Another 15.7 percent have not yet acquired dark fiber but plan to do so in the future. Doctoral institutions are much more likely to have acquired dark fiber (56.4 percent) than are master’s (25.1 percent), baccalaureate (20.2 percent), or associate’s (22.3 percent) institutions. Doctoral institutions are also the most likely to be planning future dark-fiber acquisition.

### Table 5-1. Dark Fiber Acquisitions by U.S. Research and Education Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Location</th>
<th>Segment-Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENIC</td>
<td>California + nationwide</td>
<td>6,200</td>
</tr>
<tr>
<td>FiberCo</td>
<td>Nationwide</td>
<td>5,600</td>
</tr>
<tr>
<td>SURA</td>
<td>Southern United States</td>
<td>6,000</td>
</tr>
<tr>
<td>NLR Phase 2</td>
<td>National</td>
<td>4,000</td>
</tr>
<tr>
<td>OARnet</td>
<td>Ohio</td>
<td>1,600</td>
</tr>
<tr>
<td>ORNL</td>
<td>Southeastern United States</td>
<td>900</td>
</tr>
<tr>
<td>Other regional projects</td>
<td>Various states</td>
<td>1,600</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>25,900</strong></td>
</tr>
</tbody>
</table>
Endnotes

1. B. L. Hawkins et al., EDUCAUSE Core Data Service 2003 Summary Report (Boulder, Colo.: EDUCAUSE, 2004). The 2003 Core Data Service Summary Report shows a similar pattern for bandwidths from 4.6 Mbps to more than 1,000 Mbps, but its data show significantly more respondents (21.6 percent) for bandwidth of 4.5 Mbps or less. This may be due to the difference in sample populations for the ECAR study and the core data survey, especially its larger number of small institutions.


5. The ECAR survey asked, “To which of the following does your institution connect?” so that the responses would reflect both direct and indirect connections.


9. Ibid.

10. Ibid.