Introduction

Today the world changes so quickly that in growing up we take leave not just of youth, but of the world we were young in.

—Sir Peter Brian Medawar

Providing a high-quality campus network—reliable, secure, adaptable, scalable, and fault tolerant—has become table stakes for entering and staying in the game of higher education. And the stakes are rising. Higher education’s access to information resources and services, whether they support core research and teaching missions or business administration, is increasingly central to enhancing reputation, competitiveness, client satisfaction, revenue, and accountability.

Overwhelmingly, those responding to this study indicate that their institutional leadership views their network as critical infrastructure, as a strategic resource, and as more important to the institution’s strategic goals than it was three years ago.

For some, the network is much more than table stakes. One-quarter of our respondents tell us that the network is, or will become, a competitive differentiator for their institution. This can take many imaginative forms, such as using the network to create unique student learning environments, operating successful distance-learning programs, leveraging early adoption of emerging or experimental technologies, providing a lifelong link to alumni, or enabling bleeding-edge research via very high-performance computing. A fully robust network is again the most basic underpinning for these strategic initiatives.

Perhaps this strategic focus reflects that for the first time in the history of computing, there is a real likelihood that advances in computing and communications will enable genuine breakthroughs not just in research and business, but in our core production function of learning and instruction. We sense a feeling among higher education IT leaders interviewed that the full promise of networking envisioned during the 1980s and 1990s is finally beginning to happen today. And although higher education has been cautious in adopting network-enabled teaching and learning tools, the potential is now there to truly revolutionize the delivery of education.

The pieces of the networking puzzle needed to make this a reality are coming together quickly. At the campus level, institutions are investing substantial financial and human resources to keep pace, continually reshaping campus technical architectures to support evolving technologies and applications and to support their growing and diverse campus needs. In fact, the 2004 EDUCAUSE top IT issues survey found that maintaining and upgrading network and IT infrastructure was ranked as the second highest campus IT expenditure for all Carnegie classes, public and private institutions, and both small and large institutions.1 External to the campus,
the higher education community is actively building a set of interconnecting private state, regional, and national research and education networks. Further, our community is committed to the vision of every citizen having access to our networks and is taking a proactive role in making sure this happens over the next several years.

**Higher Education as Network Pioneer**

Since networking’s inception, higher education has played a pioneering role. Partnerships between higher education, government, and industry have been instrumental in the creation and evolution of networking. Higher education’s contribution to the Internet, for example, has been not just prominent but essential. For decades, colleges and universities have been deeply involved not only in technology development but also in policy, administration, and oversight.

* ◆ 1960s. Three ideas emerging from MIT provided the foundation for today’s global networking. J.C.R. Licklider envisioned a “Galactic Network” of a globally interconnected set of communicating computers. Leonard Kleinrock’s concept of packet switching, together with Lawrence Roberts’s successful experimentation with time-sharing computers, made this vision possible.

* ◆ 1970s. Under ARPA$^2$ funding, four universities—UCLA, Stanford, UC Santa Barbara, and the University of Utah—joined to create ARPANet. The first computer-to-computer chat then took place at UCLA in 1972. The TCP/IP protocol was also developed during this era, based on the work of a Stanford team led by Vint Cerf, an MIT team led by Dave Clark, and others.

* ◆ 1980s. City University of New York instigated the BITNet cooperative and supported listserve servers, e-mail, and file transfer between higher education colleagues. Also, NSFNet (created from ARPANet) connected supercomputers at Cornell, Pittsburgh, UC San Diego, Princeton, and the University of Illinois at Urbana–Champaign.

* ◆ 1990s. Gopher was developed at the University of Minnesota, and the World Wide Web was born at CERN, the European university consortium for high-energy physics research.

Today, bleeding-edge research on an extremely wide variety of networking technologies continues to flourish within the domain of higher education. At one end of the spectrum, Larry Smarr and the OptIPuter project at the University of California, San Diego, are creating a new architecture that will let scientists generating terabytes and petabytes of data interactively visualize, analyze, and correlate their data from multiple storage sites connected to optical “supernetworks.” At the other end, Deborah Estrin at the UCLA Center for Embedded Network Sensing is developing tiny embedded networked sensing systems and applying this revolutionary technology to critical scientific and social applications.

In addition to many such research projects, the higher education IT leadership community continues to come together to accelerate progress on myriad challenging issues such as middleware, identity management, and security.

**What’s Different about Higher Education Networking?**

In the networking arena, as in most areas of higher education, the common belief is that our institutions vary significantly from other industries. The diversity of campus missions, variety of user types, breadth of technologies supported, and decentralization issues together create a higher education networking environment that differs significantly from those found in the corporate world.
Mission, User, and Equipment Diversity

Higher education institutions engage in an extremely wide range of activities. In addition to the core functions of teaching and research, they often operate student dorms, retail stores, food services, entertainment venues (sports, theater, arts), and any number of other business and cultural enterprises. Further, college and university network users can include just about anyone. Although students, staff, and faculty are the core users, remote or onsite visitors can access libraries, Web-enabled services, public kiosks, and public computer labs. This innately diverse environment translates into a diverse technical environment and a challenge for the campus network.

The technologies found at typical colleges or universities, even small ones, tend to be much more diverse than at a corporation. Institutions often don’t own many of the machines that connect to the network, such as students’ private machines connected through the dorms or libraries. Further, it is common for an institution to have computers from many vendors, running multiple operating system versions—Windows 95 to XP, several MacOS versions, and several Linux operating system variants. Server environments are also often diverse, and the overall number of standards in use can be problematic.

A Research Environment

Institutions with a research mission and focus have additional network technology and administration issues. Much research requires a network that supports experimentation, bleeding-edge technology, specialized computing (hardware and software) equipment, extremely high bandwidth requirements, protection of sensitive data, and compliance with rules covering research contracts and grants. While the corporate world can build a network to support specific, known applications, higher education network engineers have to build networks to support unknown applications. Such networks must ensure that Professor Smith can plug into the supercomputer without the campus network grinding to a halt. As University of California, San Diego’s, Larry Smarr observed, “Tracking the progress of hurricanes requires the real-time movement of terabytes of data across networks. Delays in transmission mean forecasts that can miss by miles.”

Decentralization

A decentralized culture characterizes many colleges and universities, especially those that are larger or more research intensive. In these environments, diverse schools, departments, research laboratories, hospitals, and business units can establish, tailor, and control their own local networks. This contrasts with typical corporate environments, where centralization is the norm and the central IT organization closely controls the network architecture and management, security, hardware and software purchases, user support, and most other aspects of computing within the organization. In these environments, attaining high levels of reliability, efficiency, and security is not as challenging as it is in decentralized higher education environments.

The Need for More Study: ECAR’s Role

Despite the national attention and ongoing efforts of EDUCAUSE, Internet2, the National LambdaRail, and other organizations involved in moving IT networking forward in higher education, our knowledge of colleges’ and universities’ current state of and future plans for networking is largely anecdotal. We have little quantitative information from which to benchmark IT networking.

This ECAR study is designed to provide detailed empirical information about the higher education networking environment, from both an everyday practice perspec-
itive and a strategic view. It identifies what networking technology and practices are currently in place and what future directions are anticipated and planned. Systematically gathered quantitative data can help institutions make more informed decisions about their networking approaches and plans and, we hope, contribute to the improvement of networking in higher education.

We note that although network security is critical to higher education networking, security practices and issues are outside this study’s scope. This area of investigation was covered in detail in the 2003 ECAR study *Information Technology Security: Governance, Strategy, and Practice in Higher Education.*

A navigational diagram will be used throughout this study as a framework for our discussion of findings; it appears on the title page of this chapter. At the center of our discussion is the campus network itself and its related set of network practices. Impinging on the campus network are four major forces: external networks; emerging technologies and converged networks; the future of networking; and the institutional context of organization, leadership, and management. Each of these topics will be covered as we proceed through the study chapters.

**Endnotes**

2. The Advanced Research Projects Agency (ARPA) changed its name to Defense Advanced Research Projects Agency (DARPA) in 1971, then back to ARPA in 1993, and back to DARPA in 1996.
5. The ECAR study *Information Technology Security: Governance, Strategy, and Practice in Higher Education* (Kvavik et al., Boulder, Colo.: EDUCAUSE Center for Applied Research, Research Study, Vol. 5, 2003) also discusses these issues as they relate to IT security in higher education.
6. Ibid.