Executive Summary

A walk around a college campus today reveals any number of students with cellphones glued to their ears, chatting to their friends while walking to their next class. But look a little closer and another sight emerges with growing frequency—a group of students sitting at a table in the student center, library, or classroom, clustered around their laptops and surfing the Web while working on a class project—with no network port in sight. The freedom of access that many students take for granted for voice is now expanding to data, as more higher education institutions implement wireless networks. Students use their laptops throughout the campus to check e-mail, study, or conduct research whenever and wherever it’s convenient.

And as wireless technology expands, higher education institutions feel the impact of computing freedom throughout their operations.

This report presents the results of the EDUCAUSE Center for Applied Research (ECAR) investigation with IDC, a provider of market intelligence and industry analysis, into the state of wireless networking in higher education, undertaken in a three-phase research methodology.

◆ An online survey of 391 EDUCAUSE member institutions to establish the state of wireless networking in higher education and to understand its implementation characteristics.

◆ Follow-up, in-depth telephone and on-site interviews at 17 selected institutions with information technology (IT) personnel and university members directly involved with the creation, operation, or use of wireless networks. Their comments overlay and supplement the online survey findings throughout the report.

◆ Best practices cases studies with Carnegie Mellon University, Dartmouth College, Drexel University, Indiana University, Salt Lake Community College, and The University of Tennessee to gain a deeper understanding of what has—and, as appropriate, what hasn’t—worked in wireless
implementations. These case studies provide specific examples from which other institutions can benefit in their implementations.

Key Findings

Wireless LANs are undergoing mainstream adoption within U.S. higher education. Half of EDUCAUSE members have implemented a wireless LAN, and most others (all but 8 percent) are planning for wireless. Most institutions that have implemented wireless networks are expanding them. Doctoral institutions are the pioneers and leaders in implementing wireless networking, followed by master's and baccalaureate institutions. Although associate's institutions lag, some are nevertheless implementing wireless.

The leading driver of wireless networks has been the desire to provide a greater degree of anywhere, any time network access to students. Meeting future computing needs and improving classroom and faculty access to networks are other key drivers. IT departments have been the leading proponents of wireless networks.

Wireless networking is not replacing wired networks, although it does make networking available where wired networks are difficult, impractical, or impossible to install. Wired networks will continue to be maintained and will be complemented by wireless. Higher education institutions are not forecasting the replacement of wired networks by wireless at this time.

Students have readily incorporated wireless access into their day-to-day social and academic activities, and usage is expanding. A bigger challenge, one just beginning to gain recognition, is for faculty to meaningfully incorporate wireless into the classroom curriculum. The institutions studied are beginning to enjoy success on that front, but the impacts—good and otherwise—are more complex and not yet fully visible.

While laptop PCs are the leading device for accessing wireless networks, institutions are significantly increasing access for personal digital assistants (PDAs) and even somewhat for handheld PCs. These smaller, easily portable devices will provide another layer of utility for wireless networks.

Security is the leading challenge facing wireless networks, with unauthorized access to information or unauthorized usurping of network resources as key problems. Current solutions are limited. Wired equivalency privacy (WEP) is ineffective, and virtual private networks (VPNs) are costly and inefficient. Effective, efficient solutions, such as use of the Advanced Encryption Standard (AES) in VPNs, and IEEE 802.1x/EAP (extensible authentication protocol), are one to two years away. Smaller institutions may find that appliance servers provide an effective solution.1

Support is another key issue. Wireless networks have increased the need for support—including new types of support, such as real-time classroom support.

The issue of equal access for students to wireless is being dealt with by piecemeal measures (for example, carts of laptops in labs or loaners in libraries). Mandatory laptops and wireless networking are in the beginning stages, usually in specific departments or colleges.

For those just implementing wireless networks, installation is a challenge. It is complex and time-consuming because of the inexact nature of access point placement and channel allocation. It requires learning, or at least the support of experienced wireless network contractors. Pilot implementations are valuable for learning.

Another technology challenge is bandwidth limitations of current technology (IEEE 802.11b). Most institutions are planning new technology implementations, although that also requires resources.
Overall, wireless is considered a success in higher education. The vast majority of institutions using wireless networks say they have met or exceeded their expectations. Wireless networks will increasingly be a requirement in higher education, just as wired networks already are.

**Wireless Adoption Drivers**

Wireless networking is not a new technology by today’s technology development cycles. Some institutions have used it since the mid-1990s, mainly in pilot implementations. What is new is wireless networking’s growing mainstream adoption by higher education. ECAR and IDC’s online survey of EDUCAUSE’s membership base reveals that three-quarters of its members implemented their first wireless network in the past two years. And using the EDUCAUSE membership base as a measurement, IDC found a high rate of penetration by wireless networking. About half of the members have implemented a comprehensive or specific wireless network at their institution. Another 31 percent are in the planning stages. (See Figure 1-1.)

The introduction of wireless technology standards and compliant equipment, lower network equipment and laptop costs, and the growing ranks of computer-savvy college students make it easier and more cost-effective to use wireless technology to create an instant access networking environment that students will increasingly expect. Higher education faculty demands are likely to grow as they become more familiar with wireless use in the classroom.

To understand the factors fueling wireless adoption, EDUCAUSE and IDC queried institutions in both the online survey and qualitative interviews about their reasons for implementation. The online survey respondents cited six leading factors driving the implementation of wireless networks. (See Table 1-1.)

- The most popular leading driver is the importance of improved network access for students. This is not surprising, because wireless technology untethers students, faculty, and others from traditional network access points, enabling them to work whenever, wherever they wish.
- The ability to meet future computing needs is also important to more than 40 percent of institutions, as is the ability to meet both a campus’ evolving computing needs and the expectations of prospective students.
### Table 1-1. Wireless Networking Decision Factors*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Total (N=370)</th>
<th>Doctoral (N=69)</th>
<th>Master’s (N=90)</th>
<th>Bachelor's (N=81)</th>
<th>Associate's (N=43)</th>
<th>FTE: 1-4,999 (N=198)</th>
<th>FTE: 5,000-9,999 (N=58)</th>
<th>FTE: 10,000-19,999 (N=55)</th>
<th>FTE: 20,000+ (N=21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Student Network Access at Any Time</td>
<td>51%</td>
<td>54%</td>
<td>50%</td>
<td>56%</td>
<td>47%</td>
<td>51%</td>
<td>50%</td>
<td>49%</td>
<td>67%</td>
</tr>
<tr>
<td>Student/Teacher Access During Class</td>
<td>43%</td>
<td>33%</td>
<td>44%</td>
<td>44%</td>
<td>58%</td>
<td>49%</td>
<td>36%</td>
<td>29%</td>
<td>33%</td>
</tr>
<tr>
<td>Ability to Meet Future Computing Needs</td>
<td>43%</td>
<td>41%</td>
<td>46%</td>
<td>37%</td>
<td>49%</td>
<td>42%</td>
<td>48%</td>
<td>35%</td>
<td>48%</td>
</tr>
<tr>
<td>Improved Faculty Network Access at Any Time</td>
<td>41%</td>
<td>46%</td>
<td>46%</td>
<td>38%</td>
<td>42%</td>
<td>41%</td>
<td>41%</td>
<td>36%</td>
<td>62%</td>
</tr>
<tr>
<td>Solve Specific Problem/Application</td>
<td>38%</td>
<td>25%</td>
<td>42%</td>
<td>43%</td>
<td>44%</td>
<td>44%</td>
<td>31%</td>
<td>20%</td>
<td>48%</td>
</tr>
<tr>
<td>For Institution To Be Perceived as Leading Edge</td>
<td>35%</td>
<td>43%</td>
<td>32%</td>
<td>28%</td>
<td>40%</td>
<td>34%</td>
<td>38%</td>
<td>42%</td>
<td>29%</td>
</tr>
<tr>
<td>Improved Commuter Network Access at Any Time</td>
<td>30%</td>
<td>30%</td>
<td>40%</td>
<td>28%</td>
<td>30%</td>
<td>31%</td>
<td>29%</td>
<td>27%</td>
<td>38%</td>
</tr>
<tr>
<td>Easier to Move/Add/Change</td>
<td>24%</td>
<td>10%</td>
<td>29%</td>
<td>22%</td>
<td>44%</td>
<td>28%</td>
<td>16%</td>
<td>18%</td>
<td>19%</td>
</tr>
<tr>
<td>Competitive Pressures from Other Institutions</td>
<td>21%</td>
<td>22%</td>
<td>21%</td>
<td>23%</td>
<td>21%</td>
<td>22%</td>
<td>21%</td>
<td>25%</td>
<td>10%</td>
</tr>
<tr>
<td>Savings Over Installed Wired Networks</td>
<td>21%</td>
<td>12%</td>
<td>20%</td>
<td>20%</td>
<td>33%</td>
<td>23%</td>
<td>24%</td>
<td>5%</td>
<td>19%</td>
</tr>
<tr>
<td>Operating Costs Savings Over Wired</td>
<td>11%</td>
<td>7%</td>
<td>9%</td>
<td>7%</td>
<td>19%</td>
<td>11%</td>
<td>14%</td>
<td>5%</td>
<td>19%</td>
</tr>
</tbody>
</table>

* Percentage of respondents rating specific factors as Very Important (Rated 8, 9, or 10, where 1 = Not Important, 10 = Very Important). Base: Current/planned wireless network operators, by institution type. Note: The three factors that generated the highest percentage of importance ratings are highlighted.
The increasing number of individual colleges and departments that mandate laptops for their students pushes higher education institutions to provide an appropriate supporting network infrastructure.

- More than 40 percent of the survey respondents identified network access during class time as important. As more courses incorporate e-learning elements, users view wireless access as a facilitating technology, allowing students and faculty to go online in the classroom. This is especially important at associate’s institutions.
- Not surprisingly, improved network access for faculty is important because faculty are mobile and will need to promote wireless use in classrooms.
- Small baccalaureate institutions place particular importance on finding solutions to specific problems or specific applications.
- Doctoral universities find it especially important to advance the perception that they are on the leading edge.

Wireless Network Characteristics

Many institutions phase in their wireless networks, perhaps to test the technology in a controlled situation, fulfill a specific user application, handle a building’s specific requirements, or install it as funding allows. Currently, most wireless networks are not campus-wide. Over three-quarters of online survey respondents defined their wireless network as limited to a specific building, location, or cluster of buildings.

Online survey respondents most frequently identified the computer sciences, physical sciences, and business/management departments as providing wireless access. Wireless network implementations begin at some institutions as pilots for research and experimental purposes. In addition to those mentioned above, logical departmental candidates for this research include, perhaps, the engineering departments.

IT departments place access points in hard-to-wire places in classrooms, libraries, and research facilities where—because of current building design, historical architectural significance, or other factors—it is exorbitantly expensive or impossible to wire. Wireless technology enables the IT department to redesign rooms for efficiency, not network accessibility, because workstations no longer have to be located near wall jacks or wire drops.

To promote user adoption, some institutions seed wireless technology in areas where students generally congregate. A popular testbed is the library; almost 60 percent of online survey respondents identified the library as a building with wireless access.

Business colleges and departments are frequently early adopters because their larger endowments enable them to invest in new technology. Moreover, a mandatory wireless laptop requirement is gaining popularity among MBA programs.

Institution size influences the number of wireless networks in operation. ECAR/IDC’s online survey revealed a very clear correlation between institution size (as measured by full-time enrollment) and the number of wireless initiatives, the latter increasing with larger FTE. More than three-quarters of the respondents at institutions with 20,000-plus FTE operate three or more wireless networks, compared with just 20 percent of respondents at 1–4,999 FTE institutions. Individual colleges or departments may initiate their own wireless network, but typically individual wireless network initiatives follow an institution-wide strategy that most institutions exhibit. Generally, to ensure campus-wide network compatibility and address security issues, the IT department serves as the coordinator, and often the installer, for most wireless networks.

Responses analyzed by the size of student population suggest that smaller institutions can more easily blanket their entire
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campuses with wireless coverage. Almost one-quarter of 1–4,999 FTE respondents operate a campus-wide wireless network; only 10 percent of 20,000-plus FTE respondents do. Yet larger institutions do plan to catch up, perhaps gradually weaving together a campus-wide network from their multiple wireless initiatives currently in operation at various buildings. Outdoor access is a priority for institutions with indoor wireless networks only. Many institutions that provide outdoor access currently report that it is very popular with users. Students sit at tables, benches, on the grass, or anywhere and pop open their laptops.

Trends and Directions

ECAR research observes several distinct trends in wireless usage.

Users

Many higher education institutions implement wireless technology to provide greater network access for their students and faculty as they move about the campus. And most institutions that implement wireless networks report that students readily incorporate wireless technology into their day-to-day activities.

Fewer institutions report administrative use (see Table 1-2), primarily because staff work from assigned workstations and use the wired network for access. But as FTE size grows, wireless networking extends to all constituents of the academic community.

Wireless in the Classroom

Wireless technology facilitates many institutions’ plans to incorporate e-learning tools in the classroom. Placing access points strategically throughout class buildings enables professors to bring online and interactive elements into their courses now, instead of waiting for classrooms to be wired or scrambling to reserve wired classrooms. IT administrators and users reported several benefits and ramifications of wireless networking in the classroom.

♦ Greater collaboration and communication—According to various faculty members, students use wireless in the classroom to access databases from the Web for in-class manipulation, brainstorm in a foreign language via chat functions, and conduct real-time research in conjunction with a class topic. Wireless’ impact extends to students’ work in general because they are no longer tethered to desktop PCs. Students modify the environment—whether sitting together at a table or configuring their desks into a circle—to facilitate their collaboration.

♦ Greater access to resources—Wireless enables teachers to present relevant online

<table>
<thead>
<tr>
<th>Users</th>
<th>Total (N=299)</th>
<th>FTE: 1–4,999 (N=154)</th>
<th>FTE: 5,000–9,999 (N=50)</th>
<th>FTE: 10,000–19,999 (N=45)</th>
<th>FTE: 20,000+ (N=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergrads</td>
<td>77%</td>
<td>77%</td>
<td>78%</td>
<td>76%</td>
<td>75%</td>
</tr>
<tr>
<td>Faculty</td>
<td>73%</td>
<td>65%</td>
<td>80%</td>
<td>73%</td>
<td>90%</td>
</tr>
<tr>
<td>Administration</td>
<td>53%</td>
<td>45%</td>
<td>52%</td>
<td>69%</td>
<td>85%</td>
</tr>
<tr>
<td>Grad Students/Researchers</td>
<td>44%</td>
<td>27%</td>
<td>56%</td>
<td>53%</td>
<td>95%</td>
</tr>
<tr>
<td>Other</td>
<td>6%</td>
<td>6%</td>
<td>10%</td>
<td>2%</td>
<td>5%</td>
</tr>
</tbody>
</table>

* Base: Current/piloting wireless network operators.
material in class while lecturing. More importantly, faculty members report that students use the wireless network proactively to access Web sites online during class to enrich their knowledge of the subject under discussion.

- Altered pedagogy—Although it is just one aspect of an entire technological evolution impacting higher education pedagogy in general, wireless can accelerate this evolution. More faculty members are either motivated by wireless’ ease of network access or forced by mandatory wireless laptop requirements to incorporate online resources in their classes. In either case, it takes a significant time investment to learn how to use technology in the classroom—equipment, network, and application layers—and to rethink course elements and delivery methods.

- Distraction in the classroom—Wireless’ greater access in the classroom fuels another debate: inappropriate use. Some faculty members insist that wireless laptops provide a new source for student diversion. But people are divided on the issue. Many believe it is a new angle to an old problem, class management. Most of the faculty interviewed agree that it is the faculty member’s responsibility to engage students so that they are not tempted to seek diversions such as newspapers, classroom windows, or wireless laptops. Almost two-thirds of the online survey respondents agree that wireless does not encourage inappropriate use.

### Wireless Equipment

Desktop computers are still the dominant computing device on campus, but anecdotal evidence suggests that some students and faculty members are switching to laptops. Lower prices, growing computing power, and greater portability contribute to this trend. Unsurprisingly, almost all online survey respondents identified laptop computers as a means to access the wireless network. (See Table 1-3.)

Looming on the horizon, however, are handheld PCs and PDAs. Many IT administrators and users regard the laptop as only the first step in wireless evolution. Many discussed the potential of PDAs, tablet computers, and other handheld IT devices to facilitate wireless access throughout the campus. They regard laptops as still too cumbersome for instant access because of their size and weight. They are intrigued

### Table 1-3. Devices for Accessing Wireless Networks, by Carnegie Classification*

<table>
<thead>
<tr>
<th></th>
<th>Total (N=299)</th>
<th>Doctoral (N=64)</th>
<th>Master’s (N=75)</th>
<th>Bachelor’s (N=62)</th>
<th>Associate (N=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Now</td>
<td>Add in 24 Months</td>
<td>Now</td>
<td>Add in 24 Months</td>
<td>Now</td>
</tr>
<tr>
<td>Laptop Computers</td>
<td>94% 10%</td>
<td>98% 11%</td>
<td>96% 9%</td>
<td>95% 11%</td>
<td>93% 14%</td>
</tr>
<tr>
<td>Desktop Computers</td>
<td>46% 14%</td>
<td>41% 9%</td>
<td>43% 19%</td>
<td>45% 18%</td>
<td>61% 11%</td>
</tr>
<tr>
<td>PDAs</td>
<td>39% 27%</td>
<td>53% 38%</td>
<td>40% 17%</td>
<td>24% 32%</td>
<td>21% 25%</td>
</tr>
<tr>
<td>Handheld Devices</td>
<td>9% 22%</td>
<td>16% 25%</td>
<td>8% 24%</td>
<td>5% 18%</td>
<td>4% 21%</td>
</tr>
<tr>
<td>Cellular Phones</td>
<td>4% 15%</td>
<td>5% 23%</td>
<td>3% 15%</td>
<td>2% 15%</td>
<td>4% 18%</td>
</tr>
</tbody>
</table>

* Current and planned use. Equipment type most often mentioned by respondents is highlighted.
by the potential of tablet devices, citing their larger display size compared with a PDA and their lighter weight compared with a laptop. Many observers predict that students will be pulling PDAs from their pockets, not laptops from their backpacks, to access the network, especially as more wireless networks expand outdoors. It is easier to use a PDA than a laptop while strolling across campus, and PDAs cost considerably less.

**Installation and Security**

Wireless implementation is generally a team effort, with IT taking the lead, either to coordinate efforts by individual schools, colleges, and departments or to serve as a centralized resource for smaller institutions. Naturally, this arrangement varies by institution. Specific departments and colleges are likely to be involved at doctoral institutions, reflecting their larger scope.

The wireless network planning and implementation characteristics of online survey respondents differ at institutions according to their Carnegie classification. (See Table 1-4.) The complex nature of many doctoral institutions often affects the process: Implementation time is longer, costs are greater, and the number of students served is larger. Yet their large scope enables doctoral institutions to achieve economies of scale. Their median cost per user is far lower than at other institution types. Wireless network installation is a rather complex process, requiring significant planning and testing.

Many institutions support the IEEE’s current 802.11b wireless standard in their network. Some institutions incorporate dual-bay access points to enable them to upgrade to forthcoming 802.11a or 802.11g standards and to continue supporting legacy 802.11b users.

Wireless technology’s transmission medium—the air—makes it particularly susceptible to security breaches. As a result, security is a universal concern, although luckily no institution (in the phone/on-site survey) reported any major security breaches in their wireless network. Network complexity and resources seem to affect the type of security methods institutions use. Doctoral institutions, with their complex networks, greater research activities, and larger student populations, tend to take more aggressive security steps, whereas almost 30 percent of online survey respondents at bachelor’s degrees.

### Table 1-4. Characteristics of Wireless Network Operators, by Carnegie Classification

<table>
<thead>
<tr>
<th></th>
<th>Total (N=299)</th>
<th>Doctoral (N=64)</th>
<th>Master’s (N=75)</th>
<th>Bachelor’s (N=62)</th>
<th>Associate’s (N=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Planning Time (Months)</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Median Implementation Time (Months)</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Median Amount Spent or Budgeted</td>
<td>$50,000</td>
<td>$80,000</td>
<td>$50,000</td>
<td>$20,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>Median Number of Students/Faculty That Wireless Network Serves</td>
<td>1,000</td>
<td>3,000</td>
<td>1,000</td>
<td>610</td>
<td>500</td>
</tr>
<tr>
<td>Median Cost per User</td>
<td>$50.00</td>
<td>$26.67</td>
<td>$50.00</td>
<td>$32.79</td>
<td>$60.00</td>
</tr>
</tbody>
</table>
institutions report no encryption/authentication usage. (See Table 1-5.) A higher percentage of doctoral institutions use non-WEP solutions, mainly because of dissatisfaction with the WEP standard in general. IT administrators complain about its security flaws and lack of scalability. As a result, many institutions, larger ones in particular, turn to other solutions.

**Wireless Technology’s Adaptability**

Further analysis of ECAR’s online survey results indicates distinct wireless networking characteristics by institution type. Higher education institutions range from huge, city-like research institutions to bucolic liberal arts colleges. Wireless, as an IT tool, adapts to meet needs determined by an institution’s characteristics, IT resources, and culture. ECAR examined its member survey results by Carnegie classification to find distinguishing characteristics.

**Doctoral Institutions**

As the leading early implementers, doctoral institutions have the highest percentage of respondents (37 percent) that implemented their first wireless network before 2000. The wireless implementations reflect these institutions’ more complex organization. Almost 60 percent of doctoral respondents claim to operate at least three wireless networks at their institutions. Many parties besides IT personnel are involved in the planning and implementation, including specific colleges or departments (48 percent).

Many institutions of all types reported significant wireless access in libraries and classrooms, but doctoral institutions reported the highest wireless access rate in administration (36 percent) and research centers (27 percent).

<table>
<thead>
<tr>
<th>Encryption/Authentication</th>
<th>Total (N=299)</th>
<th>Doctoral (N=64)</th>
<th>Master’s (N=75)</th>
<th>Bachelor’s (N=62)</th>
<th>Associate’s (N=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>128-Bit WEP</td>
<td>33%</td>
<td>28%</td>
<td>36%</td>
<td>31%</td>
<td>46%</td>
</tr>
<tr>
<td>40-Bit WEP</td>
<td>17%</td>
<td>9%</td>
<td>21%</td>
<td>21%</td>
<td>18%</td>
</tr>
<tr>
<td>Firewall</td>
<td>24%</td>
<td>23%</td>
<td>27%</td>
<td>15%</td>
<td>46%</td>
</tr>
<tr>
<td>RADIUS</td>
<td>18%</td>
<td>30%</td>
<td>19%</td>
<td>10%</td>
<td>14%</td>
</tr>
<tr>
<td>IP VPNS</td>
<td>14%</td>
<td>25%</td>
<td>12%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Wireless Vendor Supplied Solution</td>
<td>9%</td>
<td>8%</td>
<td>8%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Extensible Authentication Protocol</td>
<td>5%</td>
<td>6%</td>
<td>4%</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Third Party Hardware/Software Security Solution</td>
<td>5%</td>
<td>13%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Kerberos</td>
<td>3%</td>
<td>8%</td>
<td>3%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>None</td>
<td>18%</td>
<td>14%</td>
<td>16%</td>
<td>29%</td>
<td>14%</td>
</tr>
</tbody>
</table>
Many different constituents use the wireless networks. Doctoral institutions reported the highest incidence of faculty (86 percent), administration (77 percent), and graduate students/researchers (80 percent) accessing their wireless networks. In addition, doctoral institutions reported higher usage of PDAs (53 percent), handheld devices (16 percent), and cellphones (5 percent) than other institutions.

**Master’s Institutions**

Respondents displayed a combination of traditional and innovative characteristics. Wireless technology is less entrenched in master’s institutions than in doctoral institutions, but its adoption surpasses that in baccalaureate institutions. Many master’s institutions are just implementing their first wireless network; 40 percent of respondents launched their initial wireless installation in 2001. Many master’s institutions are satisfied with the results, with 23 percent of respondents stating that wireless exceeded their expectations, a higher rating than any other Carnegie category.

**Baccalaureate Institutions**

Wireless networks are a relatively new capability for many baccalaureate institutions; over half of the respondents initiated their first wireless network in 2000. The library is the center of the baccalaureates’ wireless network. Just over 60 percent offer wireless access, and 61 percent of baccalaureate institutions with wireless access report that their libraries are involved in planning and implementation—a higher percentage than in doctoral and master’s institutions. Baccalaureate institutions maintain limited wireless network operations; 61 percent of respondents utilize one wireless network, 56 percent say their wireless network is confined to specific buildings, and less than half (47 percent) plan to expand to campus-wide coverage. This is unsurprising, as baccalaureate institutions believe their wireless network will serve only about 1,500 students and faculty members, the smallest average number of users among all Carnegie classifications.

**Associate’s Institutions**

Almost one-quarter of associate’s institution respondents claim that wireless networking has a low priority in terms of overall IT strategy. Perhaps this is why many associate’s institutions are recent implementers, with more than 40 percent implementing their initial network in 2001. Despite the late start, almost 60 percent of associate’s respondents reported at least two wireless networks in operation. Almost 80 percent report that their wireless networks are limited to specific buildings or locations. The limited scope translates into fast setup time. Associate’s institutions implemented their wireless networks in an average of 2.1 months. The research seems to indicate that wireless is used for limited, targeted classroom applications.

**Challenges**

Wireless networks do present some challenges. Online survey respondents identify security as their leading challenge, and IT administrators voiced similar concerns
Security

While WEP is the most frequently used security measure, many institutions feel that WEP doesn’t provide strong security. Therefore, many institutions have already implemented, or plan to implement, a VPN, which enables them to provide a centrally managed security solution. But VPNs provide very inefficient throughput. Implementing 802.1x, when it’s available in another year or two, is another potential solution.

Some institutions tell students not to assume that the network is secure and encourage them to use Secure Sockets Layer (SSL) or Secure Shell/FTP (SSH). While few institutions report the creation of training classes specific to wireless networking, they may incorporate sections about wireless in general computer orientation sessions or post information on their Web sites.

Faculty Support Issues

Before wireless networking, technology in the classroom was already impacting the traditional classroom experience. Faculty members had begun to incorporate online teaching elements in the classroom to augment traditional lectures and to create a hands-on learning experience. Wireless technology accelerates this trend by enabling easy expansion of network capability to more classrooms, so that more faculty members can use technology elements during class.

Many institutions were not prepared for the added support requirements—that is, the additional support to train faculty members on how to use the technology in the classroom and additional resources to help faculty members create these online teaching elements. This entails technology training, on-site tech support during class, advice on pedagogy, and additional personnel resources. Some institutions created a dedicated department within their IT organizations to address these issues, but there are no definitive...
results. Another question, though not a support issue, is whether to recognize the additional time investment faculty members must make to develop new teaching elements.

**Equal Equipment Access**

Although some IT administrators and users report laptop usage on the rise, many students still use desktop PCs as their primary computing device. Naturally, there is concern about the lack of equal access to laptops and how it affects nonusers’ educational experiences. For example, how do laptop owners and nonowners work together on a project?

Some institutions implement wireless laptop checkout programs for individual students at their libraries or student centers. Students check out the laptops at no cost for a specified period. This gives institutions a way to track potential wireless demand.

For classroom or lab applications, institutions maintain carts of laptops that faculty members reserve in advance. This scheme has advantages and disadvantages. During class, all students have equal access to the laptops.

Other institutions take a more proactive stance by mandating laptops for some or all of their students. Typically, a specific college or department requires laptop ownership, so the entire student body doesn’t need them. Only 6 percent of higher education institutions require notebooks of all students; most of these are small (less than 5,000 FTE) and/or privately controlled institutions. This notebook requirement drives wireless usage. More than half of the online survey respondents with a mandatory notebook requirement also require wireless access. The wireless requirement is logical because wireless access enables students to use their notebooks more frequently, generating a higher return on their mandatory laptop investment.

**Cost of Wired and Wireless Coexistence**

A few institutions report that they built their wireless network with the expectation that it would replace some parts of the wired network. This never occurred. Instead, as online survey respondents and most interviewees confirmed, coexistence developed between their wired and wireless networks. As a result, IT departments must finance and support parallel networks. Therefore, it becomes important for institutions to develop a cost recovery model to finance future wireless network upgrades. One advantage of coexisting networks is that most IT departments use the same support resources and tools for both, and they typically operate one help desk for both networks.

**Installation Issues**

Installing a wireless network is complex and requires considerable planning. As a result, many institutions warn against skimping on this process and recommend starting with a small pilot project to gain experience. Unfortunately, no institution reported a simple, straightforward process or algorithm that makes access point placement as easy as one-two-three. Each building and each room has unique characteristics that make trial and error part of the placement process. Building architecture, construction materials, channel allocation, transmission range, room size, and room applications all affect access point and antenna placement. Even with experience, IT departments make educated guesses, but they must always test to ensure optimal placement.

**Bandwidth**

Wireless’ limited bandwidth is another issue to address. On a shared network, an
individual’s activities impact those of other people in the same area, sharing the same access point. As a result, some institutions instruct faculty members to stagger students’ wireless network log-on. Some institutions discourage users from backing up files or transmitting data-intensive files on the wireless network. Again, continual education is key. Some institutions report that by employing the wireless network so frequently, users forget about the bandwidth issue. Most institutions are planning upgrades to 802.11a or 802.11g to provide increased bandwidth.

**User Satisfaction**

Most online survey respondents, IT administrators, and wireless users report overall satisfaction with their wireless networks. (See Figure 1-3.) Many track satisfaction qualitatively through user feedback, though some institutions incorporate quantitative tools as well: number of access points deployed, number of registered users, and performance readouts from network administration tools. Most institutions cited convenience as a key benefit, which in turn facilitates greater productivity. Some users believe wireless technology enhances the classroom experience by facilitating collaboration and engaging students actively in the learning process.

**Future Plans and Strategies**

Most IT administrators plan to maintain both their wired and wireless networks in tandem. Others want to continue expanding wireless networks throughout their institutions as a way to provide ubiquitous computing. Bandwidth needs to be addressed so that institutions can provide better service and enable users to employ the wireless network for data-intensive applications like video. Not surprisingly, many respondents are monitoring 802.11a and security developments for future implementation. Users plan to continue fostering wireless networking’s adoption in the classroom by promoting its capabilities to faculty mem-

![Figure 1-3. Wireless Network Results versus Expectations*](image-url)
bers and students and by enhancing applications. Future applications with PDAs and handheld devices intrigue both IT administrators and users.

**Wireless Networking an IT Requirement**

Wireless access has become an IT requirement for higher education institutions. The penetration percentage indicates it is becoming mainstream, and students increasingly will expect to access their institution’s network from practically any place and at any time. Students themselves are fueling this phenomenon. Their technology usage habits combined with their growing preference for laptops raises their expectations for immediate information or communication. At least one interviewee mentioned that an institution’s high-tech capability is a criterion when students select an institution to attend, and wireless access enhances an institution’s attractiveness. This is more likely to be true at technical and doctoral institutions.

Many higher education institutions already recognize this trend. Ninety-two percent will implement wireless networking, and many current operators plan to continue expanding wireless access throughout their campuses. While wireless is not revolutionizing higher education’s IT infrastructure, its impact will be felt throughout the campus. Wireless enables greater interaction and e-learning inside and outside the classroom, facilitates research through easier information access, and allows the design of more productive work spaces for staff.

**Endnotes**

2. Ibid.