Further analysis of the online survey results identified numerous characteristics and trends by institution type. This chapter profiles the wireless networking deployment and usage characteristics of higher education institutions by Carnegie classification, institution profile, and full-time enrollment.

Carnegie Classification

The wireless networking activities of institutions in different Carnegie classifications vary considerably. Table 9-1 presents a snapshot view of wireless characteristics by institution type, followed by a profile of each institution type.

Doctoral

Given their extensive academic and research programs, the broad use of wireless networks at doctoral institutions isn’t surprising. Many doctoral institutions use wireless networks to connect their vast infrastructures and campuses.

Factors Driving Wireless

Wireless implementations serve a marketing role as well as a functional role within doctoral institutions. Like other institution types, doctoral institutions rated improved network access at any time for students (54 percent) and faculty (46 percent) as important reasons to implement a wireless network. Unlike other institutions, more than 40 percent of doctoral institutions identified wireless technology’s contribution to their being perceived as leading-edge institutions as an important implementation factor.

Year of Implementation

Doctoral institutions had the highest percentage of survey respondents (37 percent) that implemented their first wireless network before 2000.

Scope of Wireless Networks

Almost 60 percent of doctoral respondents claim to operate at least three wireless networks at their institutions. More than 60 percent state that their wireless networks serve a specific building, and almost three-quarters said their wireless networks offer outdoor use.

Nevertheless, expansion plans are commonplace. More than half of the doctoral institutions without a campus-wide wireless network plan to expand to campus-wide coverage. And while the mean percentage of geographic area covered by wireless networking is 26.6 percent, doctoral institutions plan to increase this to 50.6 percent in the next 24 months.
Table 9-1. Wireless Characteristics, by Carnegie Classification

<table>
<thead>
<tr>
<th>Item</th>
<th>Doctoral</th>
<th>Master’s</th>
<th>Baccalaureate</th>
<th>Associate’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implemented</td>
<td>75%</td>
<td>59%</td>
<td>45%</td>
<td>43%</td>
</tr>
<tr>
<td>Pre-2000 Adoption</td>
<td>37%</td>
<td>26%</td>
<td>15%</td>
<td>18%</td>
</tr>
<tr>
<td>Multiple WLANs</td>
<td>70%</td>
<td>43%</td>
<td>39%</td>
<td>59%</td>
</tr>
<tr>
<td>Campus-wide</td>
<td>23%</td>
<td>25%</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>72%</td>
<td>47%</td>
<td>58%</td>
<td>46%</td>
</tr>
<tr>
<td>Median Geographic Coverage Percentage</td>
<td>15%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>User Mix</td>
<td>Undergrad: 78% Faculty: 86% Admin: 77% Grad/Res: 80%</td>
<td>Undergrad: 84% Faculty: 75% Admin: 55% Grad/Res: 45%</td>
<td>Undergrad: 77% Faculty: 58% Admin: 42% Grad/Res: 18%</td>
<td>Undergrad: 61% Faculty: 54% Admin: 36% Grad/Res: 4%</td>
</tr>
<tr>
<td>Highest Identified Department Usage</td>
<td>Business: 55% Computer Science: 36% Engineering: 47%</td>
<td>Computer Science: 36% Business: 33% Physical Science: 32%</td>
<td>Physical Science: 34% Computer Science: 32% Social Science: 31%</td>
<td>Physical Science: 36% Lang/Arts/History: 25% Computer Science: 18%</td>
</tr>
<tr>
<td>Equipment Mix</td>
<td>Laptops: 98% PDAs: 53% Desktops: 41%</td>
<td>Laptops: 96% Desktops: 43% PDAs: 40%</td>
<td>Laptops: 95% Desktops: 45% PDAs: 24%</td>
<td>Laptops: 93% Desktops: 61% PDAs: 21%</td>
</tr>
<tr>
<td>Planned 802.11a Adoption</td>
<td>70%</td>
<td>56%</td>
<td>42%</td>
<td>32%</td>
</tr>
<tr>
<td>WEP Usage</td>
<td>34%</td>
<td>51%</td>
<td>45%</td>
<td>61%</td>
</tr>
<tr>
<td>IP VPN Usage</td>
<td>25%</td>
<td>12%</td>
<td>10%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Buildings with Wireless Access**

Wireless use at doctoral institutions covers a wide variety of buildings, users, and equipment. Many institutions of all types reported significant wireless access in libraries and classrooms, but more doctoral institutions reported wireless access in administration (36 percent) and research centers (27 percent).

**Users**

Students, of course, use the wireless network, but doctoral institutions reported a high incidence of use by faculty (86 percent), administration (77 percent), and graduate students/researchers (80 percent).

**Equipment Used**

Doctoral institutions reported higher usage of PDAs (53 percent), handheld devices (16 percent), and cell phones (5 percent) than other institutions.

**Installation Issues**

The organization of doctoral institutions is complex, and their wireless implementations reflect this complexity. Besides IT, many parties, including specific colleges or depart-
ments (48 percent), are involved in planning and implementation. After planning, wireless network implementation takes longer than at other institution types—5.7 months on average.

Doctoral institutions spent or budgeted more than other institution types: an average of $332,935. Almost 20 percent of the funding originated from a specific department, a far higher percentage than at other institution types.

**Standards**

Doctoral institutions’ early adoption of wireless networking and their extensive resources may allow them to adopt emerging technology more quickly than other institution types. This class was the most likely to adopt emerging IEEE 802.11a (70 percent), 802.11g (31 percent), and Bluetooth (22 percent) standards over the coming 24 months.

**Security**

Doctoral institutions are less likely to use wired equivalency privacy, or WEP, (34 percent) but more likely to use advanced solutions such as RADIUS (30 percent), IP VPN (25 percent), and Kerberos (8 percent). This class reported the highest percentage of network operators (36 percent) replacing WEP with extensible authentication protocol (EAP) 802.1x draft.

**Master’s**

Respondents at master’s institutions displayed a mixture of traditional and innovative characteristics. Wireless technology is less entrenched in master’s institutions than in doctoral institutions, but its adoption surpasses that at baccalaureate institutions.

**Factors Driving Wireless**

User need drove master’s institutions to implement wireless networks. The most important factors, according to respondents, were improved access for students (50 percent) and faculty (46 percent), and the capability to meet future computing needs (46 percent).

**Year of Implementation**

Many master’s institutions are just implementing their first wireless network; 40 percent of respondents launched their initial wireless installation in 2001.

**Multiple Initiatives**

Almost 60 percent of master’s institutions reported one wireless network in operation.

**Scope of Wireless Networks**

Three-quarters of wireless networks at master’s institutions are restricted to specific buildings or a specific location. Just half of master’s institutions reported their wireless networks are not campus-wide, though many (52 percent) do plan to expand to campus-wide coverage. Outdoor use is available at 47 percent of respondent campuses in this class.

Master’s respondents hope to double the mean percentage of campus geographic area covered from 27.6 percent to 56.6 percent in the next 24 months.

**Buildings with Wireless Access**

While wireless is still a relatively new phenomenon at master’s institutions, 20 percent of respondents reported wireless availability in dormitories—the highest response for any Carnegie class. Wireless access is available also in classrooms (51 percent) and libraries (59 percent).

Master’s institutions generated the lowest response for wireless access in administrative buildings (28 percent), and nearly 44 percent of respondents are uncertain about connecting them to their wireless networks.
Users
Master’s institutions reported the highest incidence of undergraduates (84 percent) using their wireless networks. Other parties—faculty (75 percent), administration (55 percent), and graduate students/researchers (45 percent)—access the wireless networks too, but to a lesser degree than at doctoral institutions.

Departmental Use
Computer science (36 percent), physical science (32 percent), and business (33 percent) are the departments or colleges that most often use wireless.

Equipment Used
Many respondents already connect laptops (96 percent) and desktop computers (43 percent) to their wireless network. Some respondents (24 percent) plan to add handheld devices/scanners in the next 24 months, and 19 percent are planning to add desktop computers.

Installation Issues
The mean amount spent/budgeted for wireless networking at master’s institutions was $82,968, and implementation took just 3.9 months.

Standards
While many master’s institutions (65 percent) plan to support 802.11b in the next 24 months, 56 percent of respondents plan to incorporate 802.11a, 24 percent 802.11g, and 16 percent Bluetooth.

Security
More than half of the master’s institutions use WEP, and 27 percent use firewalls.

Satisfaction
Master’s institutions are satisfied with their wireless networks; 23 percent of respondents stated that wireless exceeded their expectations—the highest response for any Carnegie class.

Baccalaureate
Wireless networks are relatively new at baccalaureate institutions. As a result, it seems that many are still seeding the technology, focusing on library implementations and gearing usage toward students.

Importance in IT Strategy
More than one-quarter of baccalaureate respondents believe the wireless network has a low priority in the overall IT strategy.

Factors Driving Wireless
Improved network access for students (56 percent), student and teacher access during class time (44 percent), and improved faculty access (38 percent) were the top three reasons baccalaureate schools gave for implementing their wireless networks.

Year of Implementation
Wireless networks are a relatively new capability for many baccalaureate institutions. More than half of the respondents initiated their first wireless local area network in 2000.

Multiple Initiatives
Like master’s institutions, many baccalaureate institutions maintain limited wireless network operations; 61 percent of respondents use a single wireless network.

Scope of Wireless Network
Fifty-six percent of baccalaureate institutions said their wireless network is confined to specific buildings, and fewer than half (47 percent) plan to expand to campus-wide coverage.

Almost 60 percent of baccalaureate institutions’ wireless networks offer outdoor
use, covering, on average, 24.6 percent of the campus’ geographic area. Baccalaureate institutions plan to increase campus geographic coverage, on average, to 46.4 percent in the next 24 months.

**Buildings with Wireless Access**
The library is the center of the baccalaureates’ wireless network; just over 60 percent offer wireless access. And 61 percent of baccalaureate institutions reported their libraries are involved in the planning/implementation process—a higher response than at doctoral and master’s institutions.

A smaller percentage of baccalaureate institutions provide wireless access to administration buildings (27 percent), classrooms (45 percent), and dormitories (16 percent) than doctoral or master’s institutions.

**Users**
Undergraduates are the primary wireless users; just over three-quarters of baccalaureate respondents identified undergraduates as wireless users. A far smaller percentage of faculty (58 percent), administrative personnel (42 percent), and graduate students/researchers (18 percent) access the wireless network in baccalaureate institutions.

Baccalaureate institutions believe their wireless network will serve only 1,518 students and faculty members, the smallest average number of users among all Carnegie institution classifications.

**Equipment Used**
While laptops predominate (95 percent), a slightly higher percentage of baccalaureate institutions reported connecting desktops to their wireless networks (45 percent).

Portable device usage—PDAs (24 percent), handheld devices (5 percent), and cellular phones (5 percent)—is lower than at doctoral and master’s institutions. Almost one-third of baccalaureate institutions, however, are interested in adding PDA access to their wireless networks within 24 months.

**Installation Issues**
More than 90 percent of baccalaureate respondents identified the IT department as the primary group to initiate wireless implementation. Other groups—a specific college/department (17 percent), library (18 percent), faculty (11 percent)—were less often involved in the process than at doctoral and master’s institutions.

The mean expenditure/budgeted amount for baccalaureate institutions was $43,588.

**Standards**
While more than three-quarters plan to support 802.11b/Wi-Fi standards in the coming 24 months, fewer baccalaureate respondents plan to support 802.11a (42 percent), 802.11g (19 percent), and Bluetooth (15 percent) than doctoral and master’s respondents.

**Security**
Security is not as important to these institutions. Fewer baccalaureate respondents (53 percent) cited security as a key challenge when implementing a wireless network—a far lower response than for doctoral and master’s institutions.

As a result, fewer baccalaureate institutions support wireless encryption or authentication. Almost 30 percent of baccalaureate respondents reported using no encryption or authentication.
Only 45 percent support WEP standards, 15 percent use firewalls, 10 percent use RADIUS, and 10 percent employ IP VPNs. These institutions, however, are slightly more inclined to use vendor-supplied solutions (11 percent).

There is less interest in replacing WEP with 802.1x draft (29 percent). Sixty-five percent do not use any levels of application encryption/authentication enforcement.

**Satisfaction**

Interestingly, baccalaureate institutions have the highest percentage of respondents (11 percent) that felt their wireless network fell short of expectations and the lowest percentage (8 percent) that felt it exceeded expectations.

**Associate’s**

Most wireless networks in associate's institutions seem to be applications-oriented. While many associate's institutions implemented their initial wireless network less than a year ago, a significant number use multiple implementations. The research suggests that wireless’ targeted application is inexpensive network access for classrooms, the most likely buildings to have wireless access. Associate's institutions reported a relatively high percentage of desktop users, and fewer associate's institutions plan campus-wide networks.

**Importance in IT Strategy**

Almost one-quarter of associate's respondents claim that the wireless network has a low priority in terms of overall strategy.

**Factors Driving Wireless**

Current student needs (47 percent), student and teacher access during class (58 percent), and the ability to meet future computing needs (49 percent) were the initial factors driving implementation.

**Year of Implementation**

More than 40 percent implemented their initial network in 2001.

**Multiple Initiatives**

Despite the late start, almost 60 percent of associate's respondents reported at least two wireless networks in operation.

**Scope of Wireless Network**

Almost 80 percent of associate's institutions reported that their wireless networks are limited to specific buildings or locations. Only 40 percent of those associate's institutions with limited networks plan to expand their coverage campus-wide, and only 46 percent of respondents reported current outdoor use. As a result, associate's institutions reported that their wireless networks cover an average of 15.2 percent of the campus’ geographic area. Respondents plan to increase coverage to an average of 54.6 percent of their geographic area in 24 months.

**Buildings with Wireless Access**

Wireless access is concentrated in classrooms, which were most often cited (39 percent) as the facility with wireless capability. Wireless access is less common in other buildings. Associate's institutions have the lowest response rate for wireless capability in the library—less than 30 percent. Although 43 percent of respondents plan to add wireless accessibility to the library, nearly 30 percent were uncertain.

Few administration buildings (29 percent) are equipped for the wireless network, and only 4 percent of respondents have connected dorms to their wireless networks. Ninety-three percent could not state definite expansion plans.

**Users**

Undergraduates (61 percent) and faculty (54 percent) make up the largest user groups.
for wireless networks. Interestingly, one-quarter of respondents identified “other” users.

**Departmental Use**
Physical sciences (36 percent) and language/arts/history (25 percent) generated the highest response for department use. More than 43 percent identified other departments that use wireless.

**Equipment Used**
While 93 percent of associate’s institutions indicated laptop usage on their wireless networks, more than 60 percent identified desktop computers—the highest percentage for desktops. There was far less interest in utilizing portable devices: PDAs (21 percent), handheld devices (4 percent), and cellular phones (4 percent).

**Installation Issues**
Limited scope translates into fast setup time. Associate’s institutions implemented their wireless networks in a mean time of 2.1 months.

**Standards**
Associate’s institutions like to use established technology; 93 percent currently support 802.11b. Fewer associate’s institutions are interested in supporting 802.11a (32 percent) and 802.11g (14 percent) than other Carnegie classifications.

**Security**
Associate’s institutions generated the highest response for WEP use (61 percent) and firewalls (46 percent). Yet more than one-third enforce changing encryption keys on a periodic basis. Only 18 percent plan to replace WEP with new standards.

**Institution Control**
Table 9-2 illustrates the differences between privately and publicly controlled institutions.

**Private Institutions**
Many private institutions strive for ubiquitous wireless access. While many reported operating one network, a significant percentage offer a campus-wide implementation with access in student dorms as well as in the library and classrooms. This translates into a higher mean expenditure than that of other institution types. Private institutions are also less concerned about security; many offer only basic security options or no options as all.

**Importance in IT Strategy**
Wireless networking is considered an important IT initiative. Almost 20 percent of private institutions reported that wireless network implementation has a high priority over other IT initiatives.

**Factors Driving Wireless**
The three most important factors that drove implementation are improved access for students (57 percent) and faculty (47 percent), and greater student and teacher access during class (47 percent).

Almost one-quarter of private institutions—the largest proportion of any institution category—rated competitive pressures from other institutions as an important factor driving implementation.

**Year of Implementation**
Wireless networking is a fairly recent addition to most private institutions; more than 80 percent of respondents reported their initial wireless implementation occurred in either 2000 or 2001.
Multiple Initiatives

Almost 60 percent of private institution respondents reported operating only one wireless network.

Scope of Wireless Network

A significant percentage of private institutions’ wireless networks have a wide scope. Twenty-eight percent reported a campus-wide implementation—the highest percentage of respondents for any institution classification. More than half of those institutions without campus-wide access plan to expand their wireless networks throughout the institution.

Table 9-2. Wireless Network Characteristics of Private vs. Public Institutions

<table>
<thead>
<tr>
<th>Item</th>
<th>Private</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implemented</td>
<td>62%</td>
<td>59%</td>
</tr>
<tr>
<td>Pre-2000 Adoption</td>
<td>18%</td>
<td>28%</td>
</tr>
<tr>
<td>Multiple WLANs</td>
<td>41%</td>
<td>61%</td>
</tr>
<tr>
<td>Campus-wide</td>
<td>28%</td>
<td>17%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>56%</td>
<td>52%</td>
</tr>
<tr>
<td>Median Geographic Coverage Percentage</td>
<td>15%</td>
<td>10%</td>
</tr>
</tbody>
</table>
| User                        | Mix Undergrad: 82%
                              | Faculty: 70%
                              | Admin: 52%
                              | Grad/Res: 37%                  | Undergrad: 73%
                              | Faculty: 74%
                              | Admin: 53%
                              | Grad/Res: 47%                  |
| Highest Identified          | Computer Science: 42%
                              | Physical Sciences: 38%
                              | Social Sciences: 31%          | Computer Science: 42%
                              | Business: 32%
                              | Physical Science: 29%          |
| Department Usage            | Laptops: 95%
                              | Desktops: 43%
                              | PDAs: 33%                      | Laptops: 93%
                              | Desktops: 46%
                              | PDAs: 42%                      |
| Equipment Mix               | Laptops: 95%
                              | Desktops: 43%
                              | PDAs: 33%                      |
| Planned 802.11a Adoption    | 57%      | 50%    |
| WEP Usage                   | 48%      | 44%    |
| IP VPN Usage                | 10%      | 17%    |

Fifty-six percent of private institutions reported an outdoor implementation. Compared with public universities, private institutions cover a larger geographic area—on average about 34 percent of the campus.

Buildings with Wireless Access

Almost two-thirds of private institutions reported wireless access in their libraries, 51 percent reported wireless access in their classrooms, and 22 percent provide wireless access in their research centers. Administrative applications are less common; only 29
percent of administrative buildings have wireless access.

Dormitories are also a priority; 22 percent reported wireless access to their dormitories, the highest respondent percentage for any institution classification.

**Users**

Private institutions reported a mean of 26.3 percent of students with access to their wireless networks—almost twice the percentage of their public institution counterparts.

As at other institutions, undergraduates are the predominate users; 82 percent of respondents reported undergraduate usage. Compared with public institutions, other college constituents are less likely to use the wireless network.

**Departmental Use**

A wide variety of departments use the wireless network: computer science (42 percent), physical sciences (38 percent), business (30 percent), language/history (28 percent), and social sciences (31 percent).

**Equipment Used**

Ninety-five percent of respondents indicated that laptop computers access the wireless network. Almost 30 percent plan to add PDA access within 24 months.

**Installation Issues**

Almost one-quarter of private institutions reported that students were at least moderately involved in the wireless planning/implementation process—the highest percentage of all institution classifications.

Private institutions spent on average more than $136,000 on their implementation, compared with an average of $126,000 for public colleges and universities.

**Security**

Fewer private (63 percent) than public institutions perceive security as a problem, and their actions reflect this attitude. Almost one-quarter reported no encryption or authentication enforcement, and almost 60 percent do not use application encryption or authentication enforcement.

Compared with their public counterparts, a slightly larger proportion will use WEP (48 percent) and firewalls (24 percent), but private institutions are less likely to use RADIUS and IP VPNs.

**Public Institutions**

Wireless network implementations reflect public institutions’ comprehensive nature. Many operate several wireless networks on campus, and many different members of the academic community not only use the networks but also are involved in their planning.

**Importance in IT Strategy**

Seventy percent of public institutions believe wireless is important, but other initiatives have higher priority.

**Factors Driving Wireless**

Forty-four percent of public institutions stated that their ability to meet future computing needs was an important factor in the implementation decision. Forty-five percent identified improved student access to the network as an important implementation factor.

**Year of Implementation**

Almost 30 percent of public institutions reported implementing their first wireless network before 2000.

**Multiple Initiatives**

Almost two-thirds of public institution respondents operate multiple wireless networks, and 40 percent reported three or more in operation.

**Scope of Wireless Network**

Given the large campus size of many public institutions, it isn’t surprising that their
wireless access is more limited than that of their private institution counterparts. Public institutions, on average, reported wireless access on less than 20 percent of their total geographic area. Only 17 percent reported campus-wide implementations.

Substantial expansion is planned. Public institutions want to increase access to an average of 50 percent of their geographic area in the next 24 months. More than half of public institutions with specific implementation plans look to expand campus-wide. About half reported current outdoor use, but an additional 24 percent plan to add outdoor access.

**Buildings with Wireless Access**

More than one-third of public institutions reported wireless access in administration buildings; 49 percent reported access in libraries, and 43 percent in classrooms.

**Users**

Fewer public (73 percent) than private institutions identified undergraduates as wireless network users, but a higher percentage of faculty (74 percent), administrative personnel (53 percent), and graduate students/researchers (47 percent) have access.

**Departmental Use**

Computer science (34 percent), business (32 percent), and physical science (29 percent) are the departments most often using the wireless network. The “other” category also generated significant response (43 percent).

**Equipment Used**

Users access the wireless network with laptops (93 percent), desktop PCs (46 percent), and PDAs (42 percent).

**Installation Issues**

Their larger scale translates into a slightly longer average planning time (4.79 months) and execution period (4.86 months) for public institutions.

Interestingly, public institutions reported spending less on average ($126,028) than private institutions, despite planning to serve more than twice as many students (an average of 5,761).

Interest in wireless technology is dispersed throughout public institutions. They reported a slightly higher frequency of non-IT groups involved in the wireless network initiation process than did private institutions. Twenty-two percent cited involvement by specific colleges/departments, 21 percent by the library, and 23 percent by faculty. Interestingly, far fewer public institutions (2 percent) indicated that students were involved in the process.

**Standards**

Most public institutions expect to support 802.11b (69 percent) and 802.11a (50 percent). Expected support for 802.11g is 26 percent and for Bluetooth 22 percent. A few public institutions indicated plans to support broadband (7 percent) and GPRS/2.5G (3 percent).

**Security**

A higher percentage of public institutions regard security as a key challenge, and their activities support this view.

Public institutions are less reliant on WEP for encryption. While 44 percent do use WEP, 22 percent reported using RADIUS, 17 percent IP VPNs, 11 percent vendor-supplied solutions, and 3 percent EAP. Almost 60 percent enforce application encryption or authentication.
**Enrollment**

As Table 9-3 illustrates, wireless networking characteristics can vary considerably with enrollment size. The following profiles expand upon these differences.

**FTE 1–4,999**

Institutions with 1–4,999 FTE are small, and their wireless networks reflect this. They operate only one wireless network, which is frequently limited to specific buildings, and few identified campus-wide expansion plans.

**Importance in IT Strategy**

More 1–4,999 FTE institutions (26 percent) reported that wireless networking has a lower IT priority than institutions with a larger FTE.

**Factors Driving Wireless**

Students drive wireless network usage; 51 percent of 1–4,999 FTE institutions considered improved student access to networks to be an important reason for implementing their wireless network. Student and

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**Table 9-3. Wireless Networking Characteristics by Enrollment Size**

<table>
<thead>
<tr>
<th>Item</th>
<th>FTE: 1–4,999</th>
<th>FTE: 5,000–9,999</th>
<th>FTE: 10,000–19,999</th>
<th>FTE: 20,000+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implemented</td>
<td>55%</td>
<td>68%</td>
<td>64%</td>
<td>65%</td>
</tr>
<tr>
<td>Pre-2000 Adoption</td>
<td>14%</td>
<td>44%</td>
<td>26%</td>
<td>40%</td>
</tr>
<tr>
<td>Multiple WLANs</td>
<td>42%</td>
<td>55%</td>
<td>65%</td>
<td>81%</td>
</tr>
<tr>
<td>Campus-wide</td>
<td>22%</td>
<td>28%</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>50%</td>
<td>52%</td>
<td>69%</td>
<td>70%</td>
</tr>
<tr>
<td>Median Geographic Coverage Percentage</td>
<td>13%</td>
<td>15%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>User Mix</td>
<td>Undergrad: 77% Faculty: 65% Admin: 45% Grad/Res: 27%</td>
<td>Undergrad: 78% Faculty: 80% Admin: 52% Grad/Res: 56%</td>
<td>Undergrad: 76% Faculty: 73% Admin: 69% Grad/Res: 53%</td>
<td>Undergrad: 75% Faculty: 90% Admin: 85% Grad/Res: 95%</td>
</tr>
<tr>
<td>Highest Identified Department Usage</td>
<td>Computer Science: 32% Physical Sciences: 30% Lang/Arts/History: 21% Social Sciences: 21%</td>
<td>Business: 44% Computer Science: 40% Physical Science: 32%</td>
<td>Business: 49% Computer Science: 44% Physical Science: 42%</td>
<td>Engineering: 75% Business: 60% Computer Science: 55%</td>
</tr>
<tr>
<td>Equipment Mix</td>
<td>Laptops: 92% Desktops: 47% PDAs: 27%</td>
<td>Laptops: 96% Desktops: 48% PDAs: 44%</td>
<td>Laptops: 100% PDAs: 44% Desktops: 31%</td>
<td>Laptops: 95% PDAs: 65% Desktops: 40%</td>
</tr>
<tr>
<td>Planned 802.11a Adoption</td>
<td>45%</td>
<td>60%</td>
<td>62%</td>
<td>75%</td>
</tr>
<tr>
<td>WEP Usage</td>
<td>53%</td>
<td>36%</td>
<td>38%</td>
<td>45%</td>
</tr>
<tr>
<td>IP VPN Usage</td>
<td>7%</td>
<td>20%</td>
<td>20%</td>
<td>40%</td>
</tr>
</tbody>
</table>
teacher access during class generated the second highest response (49 percent).

**Year of Implementation**

Many 1–4,999 FTE institutions reported that wireless networking is a recent phenomenon. Almost 40 percent launched their initial implementation in 2001, and another 45 percent implemented their first wireless network in 2000.

**Multiple Initiatives**

Almost 60 percent reported only one wireless network in operation, the highest response for all institutions by FTE category.

**Scope of Wireless Network**

Because of their smaller geographic area, many 1–4,999 FTE institutions’ wireless networks are small in scope. A typical wireless network in these institutions took only 3.5 months on average to implement, the shortest average time for any FTE category. Moreover, 1–4,999 FTE institutions spent less for implementation—an average of $66,221.

Just over half reported that their wireless network is limited to specific buildings. Almost 60 percent of 1–4,999 FTE institutions that do not offer campus-wide access do not plan to do so.

Only half of 1–4,999 FTE institution respondents—fewer than any other FTE category—reported outdoor use. However, these respondents reported the highest mean percentage of geographic area (55 percent) to be covered by wireless networking in the coming 24 months.

**Buildings with Wireless Access**

Wireless networks serve many types of buildings at 1–4,999 FTE institutions. Wireless capability was reported in administrative buildings (31 percent), the library (54 percent), and classrooms (44 percent). These institutions reported the highest incidence of wireless access in dormitories (17 percent).

**Departmental Use**

More than 40 percent reported that “other” departments access their wireless network, the highest percentage by FTE institution size. Computer science (32 percent) and physical science (30 percent) generated the highest response for identifiable department usage.

**Equipment Used**

Laptop computers (92 percent) and desktop computers (47 percent) are the most popular devices used on wireless networks at 1–4,999 FTE institutions.

Respondents reported the lowest incidence of network use with other portable devices: PDAs (27 percent), handheld devices (6 percent), and cellular phones (3 percent). Compared with other FTE categories, 1–4,999 FTE institutions aren’t especially interested in adding these devices to their network over the next 24 months. Respondents reported the lowest level of interest (47 percent) in adding any devices to their wireless network.

**Standards**

Many 1–4,999 FTE institutions (89 percent) currently support 802.11b/Wi-Fi standards, but far fewer respondents in this category are interested in supporting 802.11a (45 percent), 802.11g (19 percent), and Bluetooth (12 percent) in the next 24 months.

**Security**

Fewer 1–4,999 FTE institutions (60 percent) identified security as a key wireless networking challenge, and their actions support this claim. Almost one-quarter reported using no encryption or authentication tools; more than one-half do not use any application encryption or authentication tools.

Institutions in this category are more likely to rely on WEP encryption; 53 percent of respondents report using WEP.
Fewer respondents in this category reported the adoption of other encryption and authentication tools. Only 24 percent use firewalls, 10 percent use RADIUS, and 7 percent use IP VPNs. A smaller percentage of 1–4,999 FTE institutions plan to replace WEP with 802.1x than institutions in other FTE categories.

**Multiple Initiatives**

Fifty-five percent of 5,000–9,999 FTE institutions have at least two wireless networks in operation.

**Scope of Wireless Network**

Just over half of these institutions reported that their wireless networks are limited to specific buildings. More than half with limited implementations plan to expand to campus-wide networks. And more than 80 percent of respondents reported their wireless networks either currently offer outdoor access (52 percent) or will in the future (30 percent).

**Buildings with Wireless Access**

Fifty-four percent of 5,000–9,999 FTE institutions provide wireless access to their libraries, and 48 percent provide it to classrooms. Only 12 percent provide wireless access in their dorms, the lowest percentage for all FTE categories.

**Importance in IT Strategy**

Almost 20 percent of 5,000–9,999 FTE institutions (the highest percentage by FTE category) reported that wireless network implementation is a high priority over other IT initiatives at their institutions.

**Factors Driving Wireless**

The ability to meet future computing needs was cited by 48 percent of these institutions as an important reason for implementing wireless networking. In addition, improved student access (50 percent) and faculty access (41 percent) were identified as important implementation factors.

**Year of Implementation**

Many respondents exhibited an early commitment to the technology. Forty-four percent implemented their first wireless network before 2000; 12 percent reported their implementation occurred in 1997 or earlier.

**FTE 5,000–9,999**

Many institutions in this category exhibit a commitment to wireless technology, perhaps for research purposes. A significant percentage identified wireless networking as an important IT strategy for their institution. Many implemented their first wireless network before 2000. Faculty members are just as likely as students to use the wireless network. Security is a high priority; many 5,000–9,999 FTE institutions eschew WEP for more sophisticated solutions.

**Users**

Interestingly, a higher percentage of 5,000–9,999 FTE institutions reported greater faculty access (80 percent) than student access (78 percent) to their wireless networks.

**Departmental Use**

A significant percentage of 5,000–9,999 FTE institution respondents reported that “other” departments use their wireless networks. Respondents most frequently identified business (44 percent) and computer science (40 percent) departments as wireless network users.
Equipment Used
While many 5,000–9,999 FTE institution respondents reported wireless network access by laptops (96 percent), desktop computer access (48 percent) generated the highest response for any FTE institution category. Significant use of PDAs (44 percent), handheld devices (10 percent), and cellular phones (8 percent) was also reported.

Standards
Eighty-six percent of respondents support 802.11b/Wi-Fi standards. Current support by 5,000–9,999 FTE institutions is 20 percent for 802.11a, 6 percent for Bluetooth, and 2 percent for broadband. Sixty percent, 32 percent, and 24 percent, respectively, plan to support these standards in 24 months.

Security
While 20 percent of 5,000–9,999 FTE institutions reported no encryption or authentication enforcement, many currently use advanced solutions. WEP support is less common (36 percent) than in any other FTE category. Rather, 5,000–9,999 FTE institutions are using firewalls (26 percent), RADIUS (24 percent), and IP VPNs (20 percent). Eight percent reported using a third-party hardware/software solution, the highest percentage for any FTE category.

Almost 30 percent of respondents enforce regular changing of encryption keys—the highest percentage by FTE category.

Satisfaction
These institutions have the highest percentage of respondents reporting that wireless networking has exceeded their expectations (26 percent).

FTE 10,000–19,999
Despite the relatively recent adoption of wireless networking by 10,000–19,999 FTE institutions, many have worked to spread the technology throughout their institutions. Many operate multiple wireless networks to serve classrooms, libraries, or administration buildings. And different constituencies are involved in initiation, planning, and use of the wireless networks.

Factors Driving Wireless
Attitude may be the primary motivator. The implementation decision factor that generated the highest response—more than in any other FTE category—was wireless’ ability to bolster the perception that the institution is on the leading edge.

Cost issues were not a factor. Only 5 percent of respondents mentioned installation or operational savings compared with wired networks as an important decision factor, the lowest response by FTE category.

Year of Implementation
Almost three-quarters of 10,000–19,999 FTE respondents initiated their first wireless network in 2000 (38 percent) or 2001 (36 percent).

Multiple Initiatives
Almost two-thirds of these institutions reported more than one wireless network in operation; 52 percent reported three or more wireless networks.

Network Scope
Two-thirds of 10,000–19,999 FTE institutions reported their wireless networks are limited to specific buildings. Fifty-six percent not offering campus-wide wireless networks plan to do so in the future.

As campuses grow larger, it becomes harder to offer a campus-wide implementation; only 20 percent in this category have campus-wide wireless networks. These institutions reported an average of only 17.7 percent of their campus currently accessible to the wireless network. Coverage will increase to an average of 45 percent of campus area in 24 months. Sixty-nine percent offer outdoor access.
Buildings with Wireless Access

Thirty-three percent of 10,000–19,999 FTE institutions currently have their administrative buildings accessible to wireless networking, and 31 percent are planning such access.

Libraries are a priority for institutions in this category. Respondents reported that 71 percent currently have library access to a wireless network, and another 27 percent plan to implement wireless in their libraries within 24 months.

Almost 60 percent of respondents have classroom accessibility; another 33 percent plan to offer it within two years. Institutions in the 10,000–19,999 FTE category also reported the highest percentage of respondents who either have (16 percent) or plan to have (31 percent) their dormitories connected to the wireless networks.

Users

Many groups at 10,000–19,999 FTE institutions use the wireless network. Respondents reported undergraduate usage (76 percent), faculty usage (73 percent), administrative usage (69 percent), and graduate student/research usage (53 percent).

Departmental Use

Numerous departments use the wireless network. Forty-nine percent of respondents reported usage by the business department, 44 percent by computer sciences, and 42 percent by the physical sciences.

Equipment Used

Interestingly, 10,000–19,999 FTE institutions were the only respondents reporting 100 percent on laptop computer access. Conversely, desktop access generated the lowest response by FTE category, with only 31 percent reporting desktop PC access. PDAs (44 percent) and handheld devices (13 percent) are relatively popular too.

Installation Issues

Many groups at 10,000–19,999 FTE institutions initiated, planned, and now use their wireless networks. Most respondents (96 percent) reported involvement not only by IT departments in the initiation of wireless networks, but also by specific colleges/departments (76 percent), the library (35 percent), faculty (25 percent), and students (6 percent). This is more diverse involvement than reported by other FTE categories.

Respondents from 10,000–19,999 FTE institutions also reported that many groups were involved in planning: IT departments (100 percent), libraries (73 percent), research centers (15 percent), specific colleges (69 percent), faculty (46 percent), and students (17 percent).

Such widespread involvement lengthens the planning cycle. These institutions reported that it took 7.3 months on average to plan their wireless network implementation.

Standards

Almost 96 percent of 10,000–19,999 FTE institutions reported current support for 802.11b/Wi-Fi, the highest response by FTE category. Moreover, they are interested in supporting new standards in the future; only 9 percent of respondents didn’t know their future standards support plan.

A high percentage of respondents plan to embrace all types of new standards and technologies, not just the popular standards such as 802.11a (62 percent), 802.11g (29 percent), and Bluetooth (24 percent).

A small percentage of 10,000–19,999 FTE institution respondents plan to support broadband (9 percent), GPRS/2.5G (4 percent), UMTS/3G Cellular (2 percent), and HOMERF (2 percent).

Security

Wireless network security gains importance as enrollment grows. Eighty percent of respondents identified security as a key
challenge when implementing a wireless network.

Only 9 percent of respondents reported using no encryption or authentication security measures, and only 38 percent reported no application encryption or authentication enforcement, the lowest response by FTE category.

A significant percentage of respondents in this category use non-WEP solutions. Thirty-eight percent reported WEP support, but 24 percent use firewalls, 38 percent use RADIUS, and 20 percent use IP VPNs.

**Challenges**

Despite aggressive implementation by 10,000–19,999 FTE institutions, there may be a hint of problems on the horizon. Twenty percent believe that wireless technology was more costly than expected—the highest response by FTE category.

**Satisfaction**

While 76 percent did say wireless networking met their expectations, 9 percent felt that it fell short—again, the highest response for all FTE categories.

**FTE 20,000-Plus**

Large institutions typically use wireless networking as a network access tool throughout their operations. They are early adopters, and many operate multiple networks in libraries, classrooms, research centers, and administration buildings. They serve a broad user base: students were less often cited as users than faculty, research staff, and administration. Because the networks are pervasive, planning is more complex and involves more departments. In addition, security measures are more sophisticated.

**Importance in IT Strategy**

Almost 90 percent of 20,000-plus FTE institutions believe that wireless networking is an important IT priority, but other initiatives have higher priority.

**Factors Driving Wireless**

Network accessibility is driving wireless usage. Two-thirds of respondents identified improved student network access and 62 percent identified improved faculty access as important factors behind their wireless technology implementation.

**Year of Implementation**

Many 20,000-plus FTE institutions are early adopters of wireless networking. Only 15 percent of respondents initiated their first wireless network in 2001; 40 percent implemented their first wireless network in 1998 or 1999.

**Multiple Initiatives**

More than 80 percent of 20,000-plus FTE institutions reported that they operate at least two wireless networks, and 76 percent operate three or more.

**Scope of Wireless Network**

Only 10 percent reported campus-wide implementations, and the current average coverage by wireless networking is 13.8 percent of geographic campus area, the lowest percentage by FTE category. This isn’t surprising, given the large geographic area these campuses encompass. Yet 61 percent of 20,000-plus FTE institutions that offer limited wireless networks plan to expand campus-wide—more than any other FTE category.

Seventy percent of respondents reported current outdoor access. This category has the fewest respondents (15 percent) reporting no plans for outdoor wireless access.

**Buildings with Wireless Access**

With the exception of dormitories, 20,000-plus FTE respondents reported the
highest percentage of either current or planned wireless network access in the various campus buildings: administrative buildings, 45 percent current, 40 percent planned; libraries, 50 percent current, 40 percent planned; classrooms, 40 percent current, 50 percent planned; and research centers, 20 percent current, 50 percent planned.

**Users**

This FTE category cited undergraduate students least often as wireless network users (75 percent). Members of the academic community cited more frequently as users were faculty (90 percent), administration (85 percent), and graduate students/researchers (95 percent).

**Departmental Use**

Three-quarters of respondents identified the engineering department, 60 percent identified business, and 55 percent identified computer science as departments currently using wireless networking. As evidence of their graduate school activity, 35 percent of respondents identified law schools and 20 percent identified medical schools as users.

**Equipment Used**

While 95 percent of 20,000-plus FTE institutions reported wireless access by laptops, PDAs (65 percent) and handheld devices (15 percent) were mentioned more often than by any other FTE category. Many of the large institutions want to add more devices in the next 24 months, again generating a higher response rate by FTE category for all products: PDAs (40 percent), handheld devices (40 percent), cell phones (40 percent), desktops (25 percent), and mobile laptops (15 percent).

**Installation Issues**

Respondents from 20,000-plus FTE institutions reported the longest average implementation time—5.9 months—and the largest average amount spent or budgeted—$346,154.

Unsurprisingly, more than half of the respondents reported that a specific college or department was involved in the initiation of wireless networking at the university. Almost one-quarter identified involvement by administration—the highest response by FTE category.

**Standards**

Eighty-five percent of respondents currently support 802.11b/Wi-Fi, and more 20,000-plus FTE institutions plan to adopt new standards in the next 24 months than institutions of any other size. Seventy-five percent of respondents want to adopt 802.11a, 30 percent expressed interest in 802.11g, and 30 percent will support Bluetooth. Interestingly, no institution in this category expressed interest in supporting broadband technology.

**Security**

Ninety percent of 20,000-plus FTE institutions identified security as a key wireless networking challenge, and institutions of this size use a variety of encryption and authentication tools.

Institutions in this category report the highest usage rate for the various security methods: 45 percent use WEP, 30 percent use RADIUS, 40 percent use IP VPNs, 15 percent use third-party hardware/software, 15 percent use KERBEROS, 10 percent use the Advanced Encryption Standard, and 10 percent use EAP. Almost 45 percent of respondents plan to replace WEP with 802.1x.