Executive Summary

The challenge is to make it easy to do business with the organization in any way they want, at any time, through any channel, in any language or currency and to make [constituents] feel that they are dealing with a single, unified organization that recognizes them at any touch point.

—Siebel Systems

Most of us recognize that IT networks are now fully integrated into higher education’s core operations and are essential to its research mission, increasingly essential to business and administration, and growing in importance to its overall mission of teaching and learning. At the most fundamental level, institutions must provide a network infrastructure that is reliable, scalable, secure, adaptable, and fault tolerant. Achieving these seemingly basic underpinnings is fraught with challenges on any number of fronts—financial, political, environmental, managerial, and technical.

Nevertheless, colleges and universities are not only focusing their efforts on these basic requirements but are also further leveraging their networks to strategic ends. They’re using networking capabilities in diverse and creative ways to enhance institutional competitiveness and facilitate strategic goals. Perhaps most interesting is a sense within our community that networking’s promise as envisioned in the 1980s and 1990s is finally happening today; we now see the real possibility that current networking environments can enable transformational change in our core mission of improving student learning while also reducing instruction costs. And as network reach increases—even in many rural areas, where high-speed wireless access is now being installed—and as our campus, state, regional, and national research and education networks come together, a new wave of innovation in higher education is in sight.

At the same time, research and development of new technologies continue at an accelerated pace. Mobile devices are proliferating and evolving at light-speed, embedded chip connectivity applications are close at hand, and high-performance and grid computing are generating countless exciting opportunities for both research and teaching. Looking further out, we see that higher education continues to play a role as network pioneer, with leading-edge projects throughout the academy investigating a scope of technologies that almost defies the imagination. As one survey respondent commented, “We are just getting started. The growth we have seen in the last 10 years is only the tip of the iceberg.”

It is within this context that ECAR decided to conduct an in-depth study of IT networking in higher education. The navigational diagram at this chapter’s beginning frames our discussion throughout subsequent chapters. The diagram’s center shows the key components—the campus network itself and its related network
practices. Impinging on the campus network are four major external forces: opportunities for connectivity to external networks; the institutional context of organization, leadership, and management; current and emerging technologies and converged networks; and the future of networking.

**Methodology and Study Participants**

ECAR used a multifaceted research methodology to collect both quantitative and qualitative data about IT networking:

- a literature review to identify and clarify the study’s major elements and create a working set of hypotheses to be tested;
- consultation with the EDUCAUSE Net@EDU Integrated Communications Solutions Working Group to validate the most interesting research questions and hypotheses that would frame the quantitative survey instrument;
- a quantitative online survey of 517 EDUCAUSE member higher education institutions;
- qualitative telephone interviews with 19 higher education IT executives and managers at 13 institutions about general networking issues;
- qualitative telephone interviews with 12 higher education leaders about their view of the future of IT networking in higher education; and
- three case studies, including an institution study of voice over Internet Protocol (VoIP) at the State University College of New York at Cortland; a study of networking funding models used at Cornell University, the University of California San Diego, and the University of Wisconsin–Madison; and a study of higher education applications of mobile technology in The Netherlands done by SURF, a Dutch higher education and research partnership.

**Key Findings**

We learned much about IT networking in higher education, and several themes emerged as we reviewed our results. These themes cover a wide range of networking issues, from technical and managerial practices to speculation on future directions. Here we integrate and summarize our findings.

**Network Strategy and Goals**

Our data show that respondents believe higher education leadership fully recognizes their networks’ criticality and strategic value. Respondents overwhelmingly agree that their leadership views the campus network as

- more important than it was three years ago (94 percent),
- an essential resource (98 percent), and
- critical infrastructure (89 percent).

Further, 81 percent of respondents said their institution’s leadership also considers the campus network a strategic resource. And 28 percent of respondents characterized networking at their institution not only as strategic but also as a “strategic differentiator” for the campus.

More specifically, we looked at what respondents considered to be the primary network goal at their campus, on a scale ranging from minimizing costs to providing leading-edge services. Interestingly enough, campus approaches differ widely, and Table 1-1 shows a fairly even distribution among these goals.

This breadth of goals holds even within each Carnegie classification, with some exceptions. As we would expect, doctoral institutions cite a “leading-edge” networking goal (43 percent) much more often and a “cost-minimizing” goal (9 percent) much less often than others. Associate’s institutions are least likely to report a goal of providing “high speed for all” networking (only 19 percent) and more often opt to provide network per-
formance and services to users on the basis of their needs (33 percent). We also found that institutions that focus on providing a leading-edge network, as well as those that consider the network strategic, rate the quality of their network infrastructure—optimally designed, secure, and fault tolerant—higher than others.

Our interviewees told us they perceive their network goals as generally aligned with overall campus goals, and our data support this perception. The two most commonly identified investment drivers for networking have an institutional and academic focus: 52 percent of respondents point to needs identified by the academic community, and 47 percent point to adherence to a strategic IT plan. However, despite this reported academic focus, fewer than 15 percent of respondents say that academic leadership and faculty are usually or always involved in networking decisions about infrastructure and architecture, capacity and service levels, or funding.

### Network Funding

Given the difficult financial situations at many campuses, we were not surprised to find that 59 percent of our respondents identify inadequate funding as a barrier to the delivery of network services. However, regardless of whether funding is considered a barrier to networking, respondents report that network spending is up. Two-thirds say that network spending has increased over the past three years (mid-2001 to mid-2004), and three-fourths expect that it will again increase over the next three years (mid-2004 to mid-2007). Doctoral and master’s institutions were slightly more bullish on the future of network spending: they predicted a 10 percent (median) increase, versus a 5 percent (median) increase predicted by baccalaureate and associate’s institutions. Nationally, Forrester Research predicts “network equipment spending to grow modestly at an average CAGR (compound annual growth rate) of 4 percent.”

Further, those who don’t perceive funding as a network barrier rate the quality of their network infrastructure higher than others.

The centrality of the network infrastructure to the institution is reflected in the fact that the annual budget allocation is almost always the funding source for both central networking operations (93 percent) and network upgrades or improvements (80 percent). More than half of institutions also use capital budget allocations to fund network upgrades and improvements. About one-third of institutions use student technology fees to help finance network operations. Other chargeback mechanisms and per-port

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**Table 1-1. Primary Networking Goal**

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<thead>
<tr>
<th>Primary Goal</th>
<th>Descriptor</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Provide reliable performance and services at the lowest possible cost</td>
<td>Cost minimizer</td>
<td>20%</td>
</tr>
<tr>
<td>Provide appropriate levels of performance and services to different users on the basis of their needs</td>
<td>Demand driven</td>
<td>28%</td>
</tr>
<tr>
<td>Provide high-speed networking to the entire institution</td>
<td>High speed for all</td>
<td>26%</td>
</tr>
<tr>
<td>Provide leading-edge network performance and services to the institution</td>
<td>Leading edge</td>
<td>26%</td>
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usage fees are less common, with only about 10 percent of respondents indicating their use for funding operations.

**Outsourcing Networking Activities**

Our respondents do not generally embrace outsourcing of networking activities. Almost three-fourths say that they are either very unlikely (56 percent) or unlikely (17 percent) to outsource any networking activities in the next two years. One factor may be that colleges and universities tend to keep in house those functions they deem strategic, and as we have seen, colleges and universities largely perceive the network as strategic. About half of respondents also indicate that the diversity and complexity of the institution are sufficient to make networking best managed by the institution. Another 20 percent said that although they believe that networking will become a routine function, the costs of providing this function within the institution will remain lower than if outsourced. Only 3 percent indicated that networking would become a commodity that can be outsourced to external providers.

Other possible reasons for not outsourcing surfaced, including the fact that colleges and universities have access to a cheap, but intelligent, labor source—science, engineering, and other students. Further, higher education may be more likely to consider shared services with other institutions than traditional outsourcing. Some even posit that at institutions where the voice communications function is currently outsourced, the move to VoIP may cause institutions to bring that function back in house.

Higher education’s general reluctance to outsource is in contrast with the private sector where, according to Gartner, Inc., “Outsourcing is becoming the dominant way that enterprises buy IT services” driven by “a focus on core business, access to critical technical expertise, and optimized IT operations.” And even though network outsourcing is not common in higher education, our data does show a significant contingent of institutions (20 percent) that say they are already outsourcing at least some networking activities or are likely to do so in the future. These institutions report a variety of approaches, from outsourcing select functions such as network architecture design, user support, or residence hall networking, to outsourcing all of the IT function, including networking. Those we queried about their outsourcing practices were very positive about their experiences.

**Service-Level Agreements**

About one-quarter of our respondents use service-level agreements (SLAs) in some fashion. Most frequently they are in place for the institution as a whole or for one or more departments or schools. In a few cases, respondents said SLAs were in place for external customers, affiliate organizations, or constituent groups such as students, faculty, or staff. The most common specifications in these SLAs are for user support and the availability of specific network services. This focus on user services is consistent with Network Computing’s mid-2003 annual reader survey, which found that “the most dramatic growth spikes in SLAs were for help desks (53 percent), internal Web sites (33 percent), and external Web sites (40 percent).” Penalties for unmet SLAs most often involve an escalation process within the IT organization or the university administration; rarely are subscribing users/organizations owed some financial compensation or granted a reduced charge or fee.

We noted some controversy over SLAs’ benefits and usefulness in the IT networking context. Some respondents are very positive, indicating that SLAs allowed them to clarify expectations, roles, and responsibilities of both the university IT department and the
user. They indicate that the process and resulting contract can help avoid misunderstandings and resolve questions that will arise in the future. One observer noticed that institutions are doing more sharing of sample SLAs, and some think SLA usage is on the rise. This may be economically driven by the need to do more with less, motivating network organizations to document user relationships and specify what fees are for what services.

However, most of our respondents (74 percent) don’t use SLAs at all. There is a sense that as people have come to depend on the network for everything, the institution needs to ensure a fully reliable network, with a quick response system to handle problems that do arise. The pressure for the network to perform is so great (for example, an SLA penalty clause cannot recapture a lost e-learning class) that there is some question as to whether an SLA will buy the institution anything extra.

**The Wired Infrastructure**

Much of higher education is now fully hardwired. Respondents report that almost all faculty and staff offices are now hardwired, as are most libraries, residence halls, classrooms (single connection), and research laboratories. Institutions also report some progress in hardwiring indoor public spaces. Associate’s institutions have the strongest showing in the number of classrooms with all seats hardwired, perhaps reflecting their early focus on integrating basic technologies into teaching. Baccalaureate institutions have the strongest showing in hardwiring indoor public spaces, perhaps reflecting their focus on student community.

Respondents unequivocally tell us that they keep a strong focus on the network infrastructure, and Table 1-2 provides a snapshot of transmission media, standards, and bandwidth for our higher education sample. Although this profile looks at all institutions, we note that those with larger and more complex network environments often use higher bandwidths and transmission standards than those listed in this table.

Our campus networks are well used: the majority of respondents tell us that 90 percent or more of their staff, faculty, and students (at institutions with residence halls) log on to the network at least once a day. Student usage is significantly lower for institutions without residence halls. We also asked our respondents if they believed their network meets the needs of their primary constituencies. Most are confident that the network meets staff needs (91 percent agree), with fewer respondents perceiving that the network meets

<table>
<thead>
<tr>
<th>Table 1-2. Elements of the Networking Infrastructure</th>
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<tbody>
<tr>
<td>Most Common</td>
</tr>
<tr>
<td>Backbone transmission medium</td>
</tr>
<tr>
<td>Backbone bandwidth</td>
</tr>
<tr>
<td>Backbone transmission standard</td>
</tr>
<tr>
<td>Backbone-to-end-device transmission medium</td>
</tr>
<tr>
<td>Backbone-to-end-device wired transmission standard</td>
</tr>
<tr>
<td>Backbone-to-end-device wireless transmission standard</td>
</tr>
<tr>
<td>Commodity Internet bandwidth</td>
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faculty needs (78 percent agree) and especially student needs (only 67 percent agree).

The Wireless Infrastructure

Campuses have made good progress in building their wireless network infrastructure, and they are not stopping. Wireless network expansion is especially prevalent in areas that were not as quickly hardwired, whether because of structural issues or cost and priority. For example, indoor public spaces (from commons and dining halls to medical waiting rooms) now show an almost equal split between wired and wireless network connectivity. And wireless is finally making our vision of the 1980s realistic—to have every classroom seat connected to the network. Our data show that we now have more classroom seats connected wirelessly than via hardwire.

In addition, campuses are actively wiring outdoor spaces, with almost two-thirds of institutions providing some level of outdoor wireless and 11 percent reporting a considerable number of outdoor spaces with wireless access. Numerous respondents say that providing mobility to their students is an essential part of their campus strategic goals, and others are even providing wireless into the community. To date, doctoral institutions report the greatest installation of wireless access in classrooms, indoor public spaces, and outdoor public spaces.

Most of our respondents view wireless connectivity as supplemental to hardwired connectivity, especially where bandwidth and security are important. However, one-fifth of respondents plan to actually replace wired technology with wireless networking in one or more areas on campus—most often in classrooms, indoor public spaces, and libraries. Those who do not plan such replacement indicate three primary reasons: the insufficient performance of wireless, the fact that the wired network already provides adequate coverage, and security concerns.

National, Regional, and State Research and Education Networks

We noted much energy and enthusiasm around creating and joining private education and research networks. Two-fifths of responding institutions connect to a university system-wide network, and 43 percent connect to a state educational and research network. Regional gigaPOPs connect 25 percent of responding institutions. Which external networks institutions join relates strongly to their Carnegie class. Doctoral institutions are most often connected to all types of higher education networks, whereas master’s, baccalaureate, and associate’s institutions are more likely to join a state research and educational network and use this for any further external network connectivity.

At the state and regional level in the United States, 34 research and educational networks are now in place or being implemented, and most are moving toward a model of regional facility-based networking built with owned assets. These regional networks connect constituents to external networks, and their constituencies are growing. Completion of a national higher education research and education network infrastructure requires bringing all these individual pieces together—campus, state, regional, and national networks. The key players creating these networks also explicitly state that the higher education community has both an opportunity and a responsibility to ensure that eventually every citizen has access to these educational networks and the resources and services they offer.

These private-network initiatives have taken advantage of market conditions in the telecommunications sector by acquiring unused, or dark, fiber at affordable prices. As of September 2004, dark fiber acquisition by U.S. research and education groups is conservatively estimated to be at 25,900 segment miles. Our data supports this trend,
showing that about one-third of institutions have acquired dark fiber, and about one-third of these plan to acquire more.

**Network Reliability**

Our respondents underscored the growing importance and challenge of ensuring network reliability. As campuses have focused on building their network infrastructure and adding services, the user base has become fully dependent on the network. Yet institutions haven’t kept pace in ensuring that this now-critical infrastructure and its related services can meet the basic user expectation that it will always work. Indeed, more than half of institutions report having had one or more significant network outages within the past two years.

Network redundancy is an important part of network reliability, and our data show that we have a long way to go toward full redundancy. At the same time, we know that network redundancy must be considered in the context of institutional risk assessment as a whole: institutions often cannot afford to opt for full redundancy of their water, electrical, or life-support systems, and network redundancy can compete for the same sources of funding. Although most institutions report that they have implemented redundancy for some single points of failure (74 percent), very few (9 percent) have implemented redundancy for all single points of failure. In addition, a relatively small showing of campuses have established multiple routes off campus (37 percent), multiple routes on campus (43 percent), or multiple service providers (28 percent). Not surprisingly, given the higher risks associated with larger, more complex networks, larger institutions more likely have implemented these redundancy measures. Further, paying attention to network redundancy may make a difference. Those institutions that do so report more than others that their backbone network is both more fault tolerant and more optimally designed to meet future needs.

Perhaps more revealing is that 40 percent of our respondents report that they have no disaster recovery plan for data networking on campus. This may be a matter of priorities, funding, and perceived risk. Joel Hartman, vice provost, information technologies and resources, University of Central Florida (UCF), reports that UCF’s network and all core online services were fully operational through the three hurricanes that struck the Orlando campus in fall 2004. And again, taking the step to create a disaster recovery plan matters: institutions with a disaster recovery plan agree more often that their network infrastructure is secure, fault tolerant, and optimally designed to meet future needs.

**Network Security**

We covered IT security in higher education extensively in a 2003 ECAR study and therefore consider it outside this networking study’s scope. Nevertheless, security is very much on respondents’ minds. Almost all (97 percent) said their central IT networking group is directly responsible for data networking security, and most (69 percent) said their responsibility extends to include overall campus IT security. The executives and managers we interviewed consistently pointed to security issues as their top challenge. Brian Voss, associate vice president for telecommunications at Indiana University, agrees in his top 10 best practices countdown for 2004–2005 about choosing security as the number-one issue. “Pay attention to network security—the most critical need facing CIOs and telecommunications officers today.”

Our data corroborates this qualitative finding. Of all barriers to the delivery of network services, respondents identified security most often (63 percent). Further, security is also a strong concern when it comes to wireless and mobile connectivity. Almost half of
respondents (47 percent) identified security concerns as a reason for not replacing wired connectivity with wireless. Security may be the top issue in the private sector as well. Cisco Systems CEO John Chambers talks to between 5 and 10 customers a day when he is on the road. When asked, “If you had to boil it down to one issue that seems to come up in conversations with customers over and over, what is that?” his answer is security.6

**Converged Networks**

Higher education, like other sectors, is actively converging network infrastructures for data, voice, and video. Most respondents tell us that they lie on the adoption curve somewhere between evaluating and actually running converged networks for some applications. About half of respondents indicate that IP video streaming or desktop video conferencing is already in limited or wide use on their campuses. And most other institutions are either planning to implement or evaluating these video technologies. There is less current use of VoIP—about one-quarter of institutions. An even smaller number of institutions are currently implementing other converged services such as cable TV over the network and integrated messaging (IM). Larger institutions, including many of the doctoral institutions, are furthest along the adoption curve for converged services.

The top reason for moving to converged services reflects a user focus: to provide enhanced services (63 percent) and to combine infrastructure and support staff (42 percent) for both user convenience and cost savings. Those not yet considering convergence offer extremely practical reasons for not doing so. Most often they have higher IT priorities (65 percent) or don’t require converged services at this time (60 percent). Others (42 percent) don’t see an acceptable return on investment (ROI) or are unwilling to discard their investment in legacy technologies (33 percent). We must also note that a significant number of respondents (20 percent) are not yet considering converged services because their current network infrastructure cannot support them.

How does this trend affect the central network organization? Of those considering or implementing converged networks,7 the most common area of change is the organizational structure (143 institutions). Somewhat fewer organizations said they have made changes to central networking operations, user support, or network policies. And only 53 institutions report that they’ve changed the financial model for funding and charging for network services. Yet our qualitative interviews revealed keen interest in restructuring the funding model to reflect convergence of voice and data, a transformation seen as both desirable and necessary.

Of those institutions that have implemented converged networks, 43 percent say they have achieved cost savings and another 26 percent expect to experience cost savings eventually. In the private sector, a Meta Group survey found that “57 percent of respondents said they’ve seen marked reductions in operational costs and 60 percent cited lower circuit costs. But 36 percent reported an increase to staffing costs; 44 percent cited an increase in infrastructure costs.”8

**Voice over Internet Protocol**

Looking at VoIP in more detail, we find it to be a forefront issue both in the press and in our higher education IT community. Our data show that as of the date of our survey (June 2004), two-fifths of institutions had already committed to VoIP: 27 percent had VoIP in limited or wide use, and another 15 percent were either implementing, or will do so within the next 12 months. This adoption level falls just short of that found in an October 2004
CIO Magazine survey, in which 25.5 percent of CIOs polled said they had already installed a VoIP system and 25.9 percent said they would implement one in the next 12 months.9

Again, larger institutions or those with a primary networking goal of providing a leading-edge network are more likely to be pursuing VoIP than smaller institutions.

The most common implementation approach is to use both legacy and VoIP phones for some transition period (73 percent); smaller institutions are more likely to replace all legacy phones with VoIP phones rather than use both over a transition period. Most institutions have already combined the voice communications and data networking functions so that they report to the same organization or department (65 percent).

Institutional experience with VoIP has been mixed. Some respondents report great success; others say their implementations and pilots have been problematic. The key challenge is to attain the same level of reliability in the converged network that has been there historically with traditional voice telephony. The consensus is that VoIP is inevitable, but that caution and patience are the wisdom of the day.

Network Management

Network management, software tools, restrictions, policies, and support are increasingly crucial parts of the campus network and its practices. Looking at network management software tools, we find, as expected, extensive use of stand-alone vendor products (71 percent). However, we also found that open source network management tools—such as MRTG (multirouter traffic grapher) and Netdisco—are also in very wide use (67 percent). Another 40 percent use homegrown applications. Specifically, institutions actively use monitoring tools, most commonly for monitoring traffic, network components, server performance, and security vulnerabilities. Many also use metrics, mostly for tracking network capacity utilization and uptime. Fewer institutions track packet loss, network speeds, user satisfaction, or network latency. Network directories are almost a given, with only 20 institutions reporting that they don’t use them.

Restricting bandwidth, devices, applications, or access to external devices is very common practice, but approaches vary widely among campuses. Institutions most commonly restrict e-mail relay and access to selected TCP/IP ports, connections to selected network equipment such as hubs and routers, and use of port scanners and packet sniffers. Further, most campuses (70 percent) use packet shaping to minimize the impact of peer-to-peer (P2P) file sharing and other bandwidth-consuming applications. Institutions with resident students often separate the residence halls (51 percent). Notably, associate’s institutions place more restrictions on applications and devices than do other institutions, likely because of the relatively high level of centralization and standardization found in many two-year institutions.

Formal network policies and procedures appear to be standard practice, in place at 78 percent of institutions. Respondents characterize these policies as easily accessible and clear and easy to read. We noted less enthusiasm about their comprehensiveness, currency, and consistent enforcement. Those institutions that do have policies, and especially those that enforce them consistently, rate their network infrastructure quality higher than others.

Campuses are finding ways to provide increasing network support hours. Today, more than one-third of institutions provide extended-business-hours user support, and one-quarter now provide 24 x 7 support. Again, these tend to be larger institutions, most likely responding to their diverse and complex application set, as well as many users working off-hours.
Network Complexity

We found striking differences between small institutions and large institutions (which include most of the doctoral institutions), particularly in their profiles of networking practices. Large institutions must contend with many more network users, running a much wider and more diverse set of applications, with higher-volume operations. Researchers and graduate students often make cutting-edge use of the network, and working off-hours is the norm. Further, large institutions more often have the resources and staff to allow for early adoption of new technologies, to buy new equipment with enhanced capabilities, and to implement software management tools. As the network scales up, automation becomes imperative. While smaller institutions can often keep it simple, larger institutions do not have this luxury.

These factors translate into differences found in our survey data. For example, larger institutions are more likely to
◆ use single-mode fiber optic cable;
◆ provide higher bandwidth and transmission speeds on their backbone networks;
◆ implement network redundancy measures;
◆ provide remote access to users;
◆ require login to authentication servers;
◆ provide 24 x 7 network support hours;
◆ use advanced technologies such as storage area network (SAN) and IP multicast;
◆ implement the converged services of VoIP, video conferencing, and video streaming;
◆ use open source and homegrown network management tools;
◆ use virtual local area networks (VLANs), especially to separate organizations and to connect geographically separated users; and
◆ have formal networking policies and procedures.

Many institutions are facing these issues as they grow. E. Mike Staman, Macon State University’s Peyton Anderson Professor of Information Technology, notes that “we grew from around 2,000 to over 6,000 students almost overnight, and discovered that the networking solutions of the past no longer worked. Nothing scaled, and all of a sudden we had faculty and students demanding their choice of e-mail clients, access locations, and desktop systems. Then mobility became an issue, and next people began worrying about security, authentication, and authorization. Sometimes I’m reminded of a teenager, legs going one way, arms another, and the body (our CIO and his staff) working feverishly as they try to hold things together while they build sufficient mass and capability to sustain us into the future.”

Topics for Further Study

This study covers a wide breadth of issues, looking at today and into the future—both near-term and the 5- to 10-year time frame. While discussing the study results, we identified several areas of interest to the higher education community as future ECAR research possibilities, as either full ECAR studies or shorter research bulletin efforts. Some of the most frequent suggestions are
◆ an update of IT security practices and issues;
◆ network reliability and business continuity practices;
◆ mobility—technology, issues, and implications;
◆ embedded connectivity—technology, issues, and implications;
◆ shared services as an alternative to traditional outsourcing; and
◆ identity management.
Endnotes


7. The actual numbers may be larger because some respondents in the sample are only “considering” implementing converged services and may or may not have made changes to reflect the nature of converged services.


10. R. Kvavik et al., op. cit.