Summer 2002

ACUTA Journal of Telecommunications in Higher Education

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# Events Calendar

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ACUTA is a member-driven organization dedicated to the enhancement of teaching, learning, research, and public (community) service by providing leadership in the application of telecommunications technology for higher education.
Although we are not MIT or Cal Tech or even Purdue, the fact of the matter is that all universities are under similar pressure to provide effective and flexible technology infrastructure and networks, at a high level of sophistication, to students and faculty, whatever our mission or size.

Blaine Brownell, President
Ball State University
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Thanks to the companies who support ACUTA by advertising in our Journal.
It's hard to believe that only a year ago, Napster was the reason that ACUTA members looked to each other for help in planning and marshalling resources for bandwidth consumption management. Napster was only the tip of the coming iceberg of new information gathering, disseminating, and sharing applications. Internet time has changed planning horizons extremely rapidly. New uses for network capacity arise from both expected and unanticipated applications, spread like wildfire and either catch on to become almost an entitlement, or morph into something new and different. What doesn’t go away is the ever increasing need for speed and connectivity.

And meanwhile, management of limited resources goes on. College and university communication technologists respond to daily crises of equipment and people, while also finding time to do strategic planning for applications that have yet to be thought up. Moving from the big-iron mentality of 10- to 15-year lifespan for central infrastructure equipment to a 3-year or even less turnover in essential components means that ACUTA members are always learning to be more nimble.

Capacity planning used to mean adding trunks and long-term contracts. Now it means packet shaping, on-the-fly bandwidth allocation, shared voice and data applications on the same media, lambda switching, and other resource plans for the next wave of user demand. Tools that have been designed for long-term budget and growth analysis are being redesigned to fit near-term budget crises and immediate calls for more bandwidth consumption.

While the Internet has opened up a seemingly endless appetite for connectivity, it is often the intranet on college and university campuses that is the first to see the next challenge of potential consumption. Course management systems for student assignment submission, assignments themselves that are composed of voice, data, and streaming media content, stored lectures available on-demand, text and video chats, multimedia student profiles, music and video digital entertainment, all stretch the capacity and design of a school’s communication infrastructure. That infrastructure is made up of commodity equipment piece-parts that are easy if not cheap to update, but also cabling systems that are expensive and not designed for frequent replacement. Agile ACUTA members are using every tool they can to ensure that today's investment will keep up with at least the near-term requirements of education and research demands.

But capacity planning is more than just network related. It is also people related. As rapidly as the technologies our campuses want and need change, so must the capabilities of the staff who plan, implement, maintain, and sustain them. Good leadership means developing staff resources with all the same devotion and rigor as does network management. How can we do better? It would be obvious at the front of an ACUTA Journal to say that part of the answer is to read on. But, I will say it anyhow!

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by Scott Kahler
Indiana University
Purdue University at Indianapolis

Indiana’s I-Light: Information Technology at the Crossroads

Round my Indiana homesteads wave the cornfields, ...
From the fields there comes the breath of fresh mown hay.
—Paul Dresser, On the Banks of the Wabash, Far Away

Despite the years that have passed since 1913, when the Indiana General Assembly adopted the state song, these lyrics still evoke the dominant image for many of life in the Hoosier State: acres of softly undulating corn and fields dotted with huge pillow-rolls of hay, a patchwork landscape stitched together with streams and woodlands to form a giant, tousled quilt across the countryside. If you are one of those for whom this image of Indiana comes immediately to mind, imagine the surprise you would have felt as you were driving along outside of Indianapolis in the summer of 2001, when you glanced out your window to see not only the waving corn or fresh bales of hay, long-standing symbols of Indiana’s agricultural heritage, but also bales of fiber-optic cable as well—the next new sign of the state’s burgeoning activity and promising future in the field ... of information technology!

Or, you may have already known that Indiana University (IU) has worked diligently in recent years to become a leader among institutions of higher education in the use and application of information technology; in the process, it has helped put the state of Indiana on the map in an emerging geography of national and international networks for research and education. IU’s string of high-profile accomplishments in IT began in 1998, when the University was selected to house and manage the operations center for the Abilene Network, the backbone of Internet2, a large consortium of U.S. universities working with industry and government partners to develop and deploy the next generation of advanced
network applications and technologies. IU’s accomplishments continued with substantial grants from the Indianapolis-based Lilly Endowment to establish six different Pervasive Technology Laboratories on the core campuses of IU Bloomington and Indiana University - Purdue University Indianapolis (IUPUI), as well as to create the Indiana Genomics Initiative, a world-class biomedical research enterprise building on the strengths of the IU School of Medicine and the University’s extensive IT resources. Also among the highlights has been a Shared University Research grant from IBM that allowed IU to expand the capacity of its IBM RS/6000 Research SP to nearly 300 billion mathematical operations per second, making this supercomputer one of the top 100 most powerful in the world.

Now, to take full advantage of the research and collaborative opportunities offered by high-performance computing and massive storage infrastructures such as these, scientists at IU’s campuses in Bloomington and Indianapolis, as well as at Purdue University’s core research campus in West Lafayette, were collectively in critical need of one remaining resource: a network with much greater capacity than any other that currently existed in Indiana. Fortunately, a plan was already in place to provide this very network as well as to foster synergy among Indiana’s Internet2-connected research institutions and initiatives.

On December 11, 2001, Indiana Governor Frank O’Bannon activated I-Light, an ultra-high-speed network of optical fiber that connected the campuses of IU Bloomington, IUPUI, and Purdue University to one another and to the national Internet2 Abilene Network and from Abilene to other high-performance networks for research and education across the globe. The planning for I-Light had begun in 1998, and after the Indiana General Assembly approved a $5.3 million state appropriation to IU and Purdue in 1999, the project moved very quickly from concept to reality. At its inaugural launch only two years later, I-Light may in fact have been the first fully operational network of its kind in the nation.

Immediately, I-Light had the capacity to deliver gigabit-speed connections, creating a virtual campus network for the three major campuses of Indiana and Purdue Universities. Researchers on these campuses now have the ability to communicate over miles as if they were in the same room, enabling them to establish real-time collaborative workspaces for everything from consulting on medical diagnoses and treatments to exploring the fundamental nature of matter and the basic forces that shape the universe. As the campus network backbones at IU Bloomington, IUPUI, and Purdue expand from gigabit capacity to 10-gigabit rates and beyond, I-Light, which connects them,
will be able to match these advances through upgrades to hardware technology. University ownership of I-Light ensures that whatever future expansions of capacity are needed, it can achieve them for less than a commercial provider can. Even now, the fact that I-Light allows for multiple connections across its fibers means that the network is able to provide higher, on-demand wavelengths between research groups on the connected campuses, enabling very-high-capacity terabit connectivity when such functionality is needed. Brian D. Voss, the associate vice president for telecommunications at IU, compares this capability to a coronary bypass: "We can add as many routes as we need across the fibers, until the flow allows for all data to move in an unfettered fashion. While we need only move at one-gigabit capacities on any route—or whatever the backbone rate might be—we have the ability to simply add more connections until the flow-rate capacity meets demand."

Beyond being able to guarantee capacity—traffic without bottlenecks—across the network—ILight allows the partner universities to pool their high-end computational resources to build larger, more effective facilities for researchers and scientists. As IU expands its new teraflop-scale supercomputer to include nodes at IUPUI, Purdue's growing IBM supercomputing capability in West Lafayette will be integrated with IU resources and massive data storage to form the Indiana distributed terascale computational facility. I-Light enables these supercomputers, massive data storage facilities, and visualization environments to be assembled into vast computing grids whose capabilities are virtually unlimited, and all available in the state of Indiana. An important product of these capabilities, as Purdue President Martin Jischke has noted, is that Purdue and IU will have greater leverage and an increased potential to attract federal grants in the field of IT, thus helping the state at large gain greater force in our nation's information economy.

Myles Brand, president of Indiana University, agrees, calling I-Light a force in "illuminating the future of Indiana" as it helps to create the information technology that will be so important to the state's economic future. Indeed, many states are competing to provide fertile ground for the next national-level locus of IT development. With Indiana's central location and high quality of life, the addition of I-Light creates an attractive environment for both startup and established information-age companies: Not only does the network connect the state's three major research universities to one another, but it provides fiber onramps to national and international high-performance networks. A few seeds of local economic development planted by I-Light have in fact already begun to grow: The city of Bloomington was able to leverage the initiative by adding two empty conduits to connect that city's new carrier hotel (see note) to the regional facilities in Indianapolis, and
the greater Lafayette area has launched a project to develop a comprehensive plan for a fiber infrastructure in that region as well.

The state of Indiana was already home to the Internet2 Abilene Network Operations Center, managed by IU on the campus of IUPUI, as well as one of Internet2's primary regional aggregation points—the Indiana GigaPop. Now, with I-Light not only connecting IU Bloomington, IUPUI, and Purdue, but serving as a digital onramp to extend access to high-performance networks for research and education further into the Heartland, Indiana's position as "the crossroads of America" has taken on new meaning. There are still acres of waving corn and fields of new mown hay across the state, a long celebrated intersection for diverse modes of transportation. However, as Indiana's reputation as an institution at a crossroads in digital communications on the map of advanced networking continues to grow, perhaps fewer people will be surprised to see the corn and hay side-by-side with signs of a sophisticated IT infrastructure that is dedicated to the exchange of information and ideas, the work of minds across Indiana and around the globe that will surely, bit by bit, change our world.

Scott Kahler is a senior communications specialist in the Communications and Planning Office at IUPUI. He can be reached at sbkahler@iupui.edu. Scott says special thanks to Karen Adams, Christine Fitzpatrick, Jan Holloway, and all the others whose previous work on I-Light made this article possible.

Note: A carrier hotel is a building in which Internet firms and telecommunications companies may house their computers, (e.g., servers), to store and deliver information, and switching gear, which directs voice and data traffic between long-distance carriers and local networks.
Parents with teenage children come closest to knowing the true feelings expressed by college researchers and other early Internet users. Both invested in and maintained a handy, robust communications system—originally intended for their own use. For parents, it was the telephone. For universities, it was the Internet.

In both cases, someone else discovered how handy the system could be. Suddenly, trying to find some free bandwidth became a nightmare.

Enter Internet2 (www.internet2.edu). Just like the beleaguered parents who get another phone line, Internet2 promises to provide a dedicated, high-bandwidth, always-available alternative to the original Internet.

Internet2 is a university-led research and development consortium that developed an ultrahigh bandwidth, IP-based OC-48 network for voice, data, and video traffic. More than 190 R-1 universities kicked off the partnership with industry and government to develop and deploy advanced network applications and technologies. The goals of Internet2 are the following:

- To create a leading edge network capability for the national research community,
- To enable revolutionary Internet applications,
- To ensure the rapid transfer of new network services and applications to the broader Internet community.

Today, the scope is expanding beyond the R-1 schools to smaller colleges and community colleges.

First H.323 I2 Call
To that end, on December 17, 2001, Indiana University (IU) and Texas A&M successfully prototyped and completed the first H.323 standards-based, IP-telephony call made over Internet2. It was the first time that VoIP calls have been made over Internet2 between two different phone systems on two geographically dispersed campuses. H.323 gatekeepers brokered the calls.

“I was pleased with it,” says Michael Enyert, VoIP specialist in the office of the vice president for information technology at IU. They are operating the network on a variety of PBXs, ranging from a DMS-100 at Bloomington to a SL 100 at Indianapolis.

This is no experiment, Enyert emphasizes. “We are building a production I2 network,” he says.
IU in Indianapolis is home to Internet2’s Abilene Network Operations Center (NOC), managed by IU on the Indiana University-Purdue University Indianapolis (IUPUI) campus, as well as the site of the Indiana GigaPoP, one of Internet2’s regional network aggregation points. Location helped IU get the Abilene NOC, since Indianapolis is centrally located on Qwest’s fiber-backbone network. Both IU and Purdue have been charter partners in Internet2 since its inception in the late 1990s, and IU president Myles Brand is a member of the I2 Board of Directors.

Abilene is a high-speed network supporting Internet2 applications development and demonstrating next-gen applications and quality-of-service capability. The VoIP call worked fine.

“You couldn’t tell the difference in quality from a toll call,” says Walt Magnussen, associate director of telecommunications at Texas A&M University, College Station. Enyert agrees that the calls were toll quality.

For 12 VoIP calls plenty of bandwidth is available. “With the Abilene network, congestion is simply not an issue,” Magnussen says. They used a G.711 codec and had 32 Kb and 64 Kb voice available.

“I wouldn’t even try a call like that on Internet 1,” Magnussen says. “There’d be too much testing on the links.”

The team got a large and complex lab pilot project off the ground in a few weeks. The project succeeded so well, so quickly because of the team effort between the universities and their commercial partners, Cisco (www.cisco.com, San Jose, Calif.) and Greenwich Technology Partners (www.greenwichtech.com, White Plains, NY).

“Like everything else in this business, initially it was a royal pain,” Magnussen recalls. “It was a lot of trouble. But since this was part of the I2 testbed, we got a considerable amount of support from the vendor community. Now it’s pretty straightforward—as long as you have the right equipment on the other end.”

IU built a prototype network to enable standards-based IP-telephony communications across Internet2 with the help of Cisco Avid technology. GTP, a network infrastructure consulting and engineering company, was called in to set up this pilot lab.

Enyert says they are using a variety of endpoints including 7960 phones and 7940s. There are some...
I-Light
Indiana University, Purdue University, and the state of Indiana now have their own optical fiber network called I-Light (see the story on page 6). It links researchers at the two universities with each other, and also with colleagues at other research institutions. I-Light acts as a digital on-ramp, extending the access to Internet2 and other high-speed research networks out further into the heart of the state to IU at Bloomington and Purdue at West Lafayette.

I-Light delivers gigabit-speed connections and will expand to deliver multiples of 10-gigabit connections. Essentially, I-Light creates a virtual campus network for the three major campuses of Indiana and Purdue Universities.

"Indiana University and Indianapolis have been integral to the success of Internet2," says Douglas van Houweling, president and CEO of the University Corporation for Advanced Internet Development. "With I-Light, the state of Indiana is taking a lead role by providing the foundation upon which the future of Internet technology can be built."

Seattle Central Community College
The Abilene Network is far reaching. Seattle Central Community College (SCCC) was probably the first community college on the network. It teamed with the nearby University of Washington, an R-1 school, for connectivity.

"We were in the vanguard," say Ron Hamberg, vice president for instruction at SCCC. "We saw the opportunity to participate and we said sure. For a small entrance fee, we were able to get involved with something new."

SCCC spent about $40,000 for equipment to enable them to send and receive at 12 speeds. I2's network will be a lynchpin for the community college's outreach program with distance education. Because of I2's speed, SCCC will be able to expand its community programs despite its limited facility space.

"Faculty will be able to hit a link and stream digital images into their classrooms," Hamberg says. "It is like we are re-inventing TV, only over the Internet rather than the conventional way. With high speed access, the result is starting to look like TV."

Internally, SCCC can transmit information at lightening speed among its south, north and central campuses. Hamberg says he believes the large R-1 schools recognized the advantages of extending access.

Polycom conferencing units. The softphones are 7910 and 7935s. In addition, they are using some Symbol 802.11 phones.

The project positions Internet2 to move to the forefront of standards leadership. I2 should ultimately evolve as the blueprint for improving the current Internet.

By late March, seven universities were peered on the network, including AARNet, the Australian university network; Texas A&M; CESNET, in Czechoslovakia; the Federal University of Rio de Janeiro; the University of Florida; the University of Illinois at Urbana-Champaign; IU; Penn State; and the University of Virginia.

"We took 30 man days and went in to add on applications and develop a working system," says Bob Twigg, managing partner with GTP. GTP was chosen as consultants for this project because of its proficiency with Avid skills and the top rankings that it earns in Cisco's customer satisfaction ratings.

This prototype lab was designed to serve 50,000 students on the two campuses and to enable any university to join into the network, regardless of the type of IP telephony products used on their campuses.

It was quickly obvious that a standards-based IP telephony solution would be the best bet. Although GTP is a Cisco contractor, there were other vendors' products to be connected.

"To make that call we had to log on to Internet2 to get the DNS and dial-plan configuration information," Twigg says. This was all H.323 based, so it was possible to interconnect with all the equipment. "That is truly important because they are trying to make sure that anyone who follows the standards can communicate with the rest of the universities on I2."

Twigg says that they interconnected phone systems at IU and Texas A&M's switches. IU has both DMS 100 and 5ESS switches on campus. A&M has a 5ESS. When the interconnection was completed, it was possible for a caller on both campuses to dial anywhere on either campus by dialing 8 or 9.

"We interconnected the two phone systems and interconnected the dial plan. If you wanted to go across to the other campus, based on the dial plans, you could hit one key and it would send you to the other campus. So, a caller in Texas had local access to Indiana.

The pilot lab included Cisco Call Manager softswitches and a selection of third-party IP telephony soft phones including: Symbol Wireless Netvision Data Phones; IP Blue soft phones; and the IPAQ, Compaq's hand-held, WindowsCE wireless soft phone. It also included an IP-
based customer interaction center application from Interactive Intelligence.

Cisco Call Manager softswitches and other third-party software involved in the pilot register with the standards-based VoIP Call Plan, 12GK.iiu.edu, required for all standard VoIP dial plans over Internet2.

GTP’s goal was to provide IU with a standard reference architecture that they could build on, drawing on extensive experience in creating and delivering fluid prototype labs that clearly demonstrate the functionality and performance of multiple products working together in a characteristic customer environment (scenario-based testing).

Magnussen notes that this does not mean universities will move away from the original Internet. Just like the harried parents, they will have a dedicated alternative.

**Latest Demand Figures**

Some skeptics question the need for a second parallel Internet. Yet, objective, government-developed data suggests that Internet2 is necessary. The February 2002 report by the U.S. Department of Commerce, “A Nation Online,” underscores the burgeoning demand for Internet use. The Commerce Department found 2 million new Internet users per month, all competing for time and space that formerly was the domain of university researchers and government employees.

“In September 2001, 143 million Americans were using the Internet—an increase of 26 million in 12 months,” the Commerce Department report states. “Internet use is increasing for people regardless of income, education, age, race, ethnicity, or gender.”

Eighty percent of Americans still access the Internet through dial-up service, but that will change. As the change occurs, so too will pressure on the traditional Internet. “Residential use of broadband service is rapidly expanding,” the Commerce Department confirms. “Between August 2000 and September 2001, residential use of high-speed, broadband service doubled.” As those people make more use of the Internet, any capacity glut disappears. Business, games, data transfer, and voice calls combine to cram the Internet.

Worldwide, the trend is easily confirmed. By the beginning of last year, according to research by the International Telecommunications Union, an agency of the United Nations, one in 33 voice calls already used the Internet. ITU puts the potential market for Internet telephone at about 1.5 billion users.

ITU says the growth in net voice calls has gone from about zero in 1997 to just over three percent of the international total by 2000. That amounts to about 4 billion minutes that never showed up on the bottom line at any long-distance carrier or PTT. ITU further states that, by 2004, as much as 40 percent of all international telephone traffic will be Internet based.

Cost was the original driver of Internet phone calls and remains a major factor. Much of the original work was done by Israeli telecom lab workers who were looking for a way to call friends attending college in the United States but were unable to afford PTT-controlled tariffs that exceeded $7.50 a minute.

Friends of friends heard about the IP-based calls and asked for the software. It was not long until the developers were marketing the goods.

Back in the early 1990s, Internet calls were a computer-to-computer thing. The next step was to allow someone with a PC to call a regular phone number, but not vice versa. It was around 1997 that people with typical phone handsets could make calls that were almost entirely Internet-based.

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Companies like Net2Phone, USA GlobalLink, and IDT took the technology to the mass market. AT&T introduced a product in late 1997 (but did not publicize it much for fear of parasitising its traditional long-distance revenue sources). The German PTT Deutsche Telekom also began offering Internet telephony in 1997. Now it is almost commonplace.

The Future
Once all schools are connected, calls anywhere on the IP network will be local calls. “AT&T and Sprint won’t be happy with it, but once you get all 192 locations up you can use the local exchange to talk to anyone on Internet2,” Twigg says.

Magnussen notes that there is a safeguard: Any school can talk to any other on-net school, but the call can go no further. There is no off-net dialing allowed. “We don’t want to violate the ‘appropriate use’ standards,” he says.

Magnussen also expects conference calls—such as ACUTA’s regular board and committee meetings—to be handled over Internet2. “Folks will get better-than-toll quality audio conferencing on I2 without the costs of a conference bridge,” he predicts. They likely will use 722 codecs to achieve 7-kHz audio, which is production quality.

Enyert is using 7206 routers with T1 cards in them, both as gateways and as gatekeepers. But he would hesitate to detail a system for any other school. “There is a lot a variability,” he says. For one thing, at IU they are using only H.323.

“It works fine,” Enyert says. Cisco, however, seems to prefer Media gateway control protocol (MGCP). “That is so devices are not independent. I think Cisco feels MGCP gives better integration,” he adds. There are competing standards as well, including the popular Session Initiation protocol (SIP), stream control transport protocol (SCTP), and Internet protocol device control (IPDC).

Look for a lot of competition among vendors to supply the requisite boxes and technology to link to Internet2. Cisco, whose CEO is an Indiana University graduate, wants the inside track over competitors like Nortel. To that end, they will offer standard sets of product offerings, in effect cookbook-style packages for Internet2 connectivity. A school will be able to order a set of Avid or Unity offerings with predefined, packaged configurations for 100 phones or 5,000 phones at a fixed cost. All gear will be compliant with the standards.

The menu will be a la carte: To a basic package schools will be able to add softphone capability for transportability, making another package. Consulting packages at a set rate will be available as will other services such as provisioning support. All recommendations will have the approval of the I2’s Steering Committee, Twigg says.

Internet2 is not for everyone, Magnussen says. Many schools have sharp divisions between their data and voice shops. “Voice over IP is not equally accepted everywhere. Some schools will not get it at all,” he continues.

While some simply see the data network as transport, that, too, could change as administrators continue to look for ways to squeeze dollars and discover that I2 offers financial, as well as service, advantages to the university community.

Ron Hamberg, vice president for instruction at Seattle Central Community College (see sidebar), says faculty will have to learn to use I2’s capabilities just as they had to learn PowerPoint. “I2 has the ability to level the playing field for education. It brings resources that remote, smaller, and less-wealthy institutions have not had,” Hamberg says. He ponders the time when SCCC students will be able to access the Hubble telescope and see what is happening.

“I2 is an opportunity to expand learning at a lower cost,” he concludes.

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The New Information Highway: Take 2

by Jim Romeo

Bandwidth: In the educational community, it can bridge thinking minds.

When the Internet was developed back in the 1970s by an agency of the U.S. Department of Defense, the idea was to connect researchers in various parts of the country. No longer a part of the government, the high-tech network is now used by millions of people around the world for research, business, and pleasure. Tomorrow's Internet is changing.

Enter Internet2.

Internet2 is a consortium led by more than 190 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet.

"Originally, the Internet grew out of efforts to establish network connections between research facilities" explains Don McLaughlin, director of the Office of Academic Computing at West Virginia University in Morgantown. "Initially, this was occurring in government-sponsored labs, but it quickly spread to universities. For a while, it was used substantially to support research efforts and collaborations among and between research centers and university research labs. As the Internet turned public, it quickly became congested, and researchers could not depend on it as a reliable means to communicate and transfer data. The impetus for Internet2, then, was to provide the research community with a conduit for scientific communications that would not be encumbered by the exponential growth in the Internet by business and the general public. From the perspective of a major research university, Internet2 provides a means for researchers to collaborate, share data, and perform remote data collection and processing."

What Does Internet2 Enable?
The fruits of the new network are seen in what it does for the university community. Today's university community seeks collaboration. Scientists, students, and professionals need to work together in virtual environments and conduct streaming videoconferences with high-definition television (HDTV). Consider the following examples:

- By using videoconferencing over high-performance networks, students can interact, in real-time, with some of the world's foremost master teachers of instrumental music. This past year, a student at the University of Oklahoma had real-time lessons with a master teacher from Columbia University. The MPEG-2 videoconferencing equipment at Columbia and the University of Oklahoma provides broadcast quality point-to-point and multipoint videoconferencing services at transmission speeds of 7–15 Mbps. This type of high-speed transmission, with minimal network delay, allows the type of full-motion (30 frames per second) video
and accurate representation of sound that make it feasible for musicians to collaborate from remote locations.

- At Indiana University, Drs. Gary L. Pavlis and Michael W. Hamburger, both geologists, run the first-ever seismic network in the State of Indiana with area high schools. Each school has a research-quality seismic sensor that records both local earthquakes and large distant earthquakes that produce low-frequency waves. These sensors are connected to a PC-based digitizer at Indiana University that transmits data continuously in near-real time via Internet2, providing preliminary location and magnitude information within approximately 5 minutes of a major event. Participating schools have used this initiative as a basis for innovative science projects with physics and earth science students, helping to provide a better perspective on real science.

- Susan Tennant, assistant professor of media arts and science in Indiana University's School of Informatics, has used the Internet2 network to enable geographically scattered users to explore a virtual re-creation of the Mayan city of Chichen Itza. The Abilene network delivers real-time, high-bandwidth, 3-D–rendered images that immerse into a virtual reality-enhanced, cinematic, and interactive tour of the ancient city—guided from multiple points of view: that of a Mayan priest, slave, or warrior. These images allow users to experience the architecture and artifacts as well as listen to enticing narration that places the user inside the ruins with authentic sounds, stories, and video.

- Artist Margaret Dolinsky, assistant professor in Indiana University's Henry Radford Hope School of Fine Arts, creates art environments where real-time, 3-D imagery, sound design, and elements of video are manipulated and combined with human experience for interactive exhibition and dramatic spectacle. This experience is rendered in the automatic virtual environment termed “CAVE,” in which social landscapes based on visual metaphors are created to guide participants' experiences and cognition. These firsthand sensory involvements (i.e., pursuing an object of desire or having a face-to-face confrontation) allow participants to develop personal meaning and significance in virtual environments. Participants cooperate between CAVE systems that are linked in a symbiotic relationship across the Internet2 network to unite in the culmination and realization of the artwork. Remote participants are portrayed through motion-activated graphics where control of a graphical output is created by their performance, choices, and actions. The action is guided by providing metaphorical imagery in a nonlinear narrative to offer modes for interaction and to exploit perception in virtual environments.

While use in academic disciplines is key, Internet2 is also a useful tool for administration. When Internet2 member universities held a meeting last fall, an uncertain travel environment in the wake of September 11 gave them good reason to use the Internet2 network to hold the session via computer rather than in person.

“We made a decision,” said Gary Bachula, an official of the Internet2 consortium, “to convert that into a virtual meeting. We had sessions that originated from Ann Arbor, Michigan, from Washington, DC, and from literally around the country. People on college campuses or anywhere could click on their desktop computer and access our sessions. We even set up a virtual lobby where people could chat between sessions. We tried to recreate, to some extent, the sense of what would happen if you went to a professional meeting.” Bachula feels that there is still no total substitute for face-to-face meetings, but it does provide a way to overcome obstacles to air travel, medical quarantines, or other barriers. As he put it, “These new technologies will allow our country to keep doing business.”

It's Not Free
The Internet2 initiative connects people from all over the world and has some remarkable implications for future frontiers—but it is not free of charge. Funding comes from a variety of sources. The federal government sponsored early adopters with grants from the National Science Foundation. Some of the vendors involved donated substantial value in equipment and services, but most universities are paying for Internet2 from their own funds. Internet2 universities have committed over $80 M per year in new investments on their own campuses, and corporate members have committed more than $30M over the life of the project.

The bad news is that there are many costs for any institution to consider, depending on their participation. Richard Parker, the director of academic computing at Harvey Mudd College in Claremont, California, explains that incremental costs fall into...
three categories: membership fees to join Internet2, bandwidth from campus to Internet2, and on-campus networking infrastructure.

The good news, as Parker points out, is that over the past 2 years, costs in each category have come down. Membership fees are significantly reduced because a campus can join a regional Internet2 network. The cost for bandwidth also has come down, in part because of direct reductions in costs and in part because the regional Internet2 networks allow connection at lower bandwidths.

“For an institution starting with no network in place, the cost of the on-campus networking infrastructure would be the largest,” says Parker. “Of course, most campuses already have a network infrastructure in place. In fact, many elite, small, liberal arts colleges have a more reliable and more ubiquitous network in place than major research universities such as those initially shaping Internet2.” Liberal arts colleges have networked everyone on campus from faculty offices to research labs, humanities faculty as well as science faculty, student residences, classrooms, and administrative offices. With a solid network infrastructure in place and costs on the decline, Internet2 isn’t so cost prohibitive. Places that have a weak campus infrastructure in place are going to find it more challenging to fully participate in Internet2.

For the IT and Telecom Manager: A Worthwhile Venture
Raymond F. von Dran, dean of the School of Information Studies at Syracuse University, feels it’s the “new, new information highway.”

“Internet 2 relieves the congestion on the commodity Internet since all traffic between universities is automatically routed over to Internet 2,” explains von Dran.

This highway allows thinking minds to collaborate. “I view it very much as if I had a store, with wares and customers, and that someone built an off-ramp to a special freeway that would connect me with others in my line of work,” explains Brian D. Voss, associate vice president for telecommunications at Indiana University. “Thus, I could serve other customers beyond my region, and my customers could avail themselves of products and services from other stores. In our case, the products and services are research, information, and educational resources. Continuing the analogy, I think it makes my store much more valuable to my community—and gives my community a chance to plug in to a wide array of resources. Definitely a win-win situation!”

Jim Romeo is a freelance writer based in Chesapeake, Virginia and author of Net Know-How. Surviving the Bloodbath. Straight Talk From 25 Internet Entrepreneurs

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CWRU Implements Gigabit LAN to the Desktop

by Phil Lillies

With programs in health sciences, law, management, engineering, social work, and arts and sciences, Case Western Reserve University (CWRU) in Cleveland, Ohio, is one of the nation’s leading independent research universities. CWRU enrolls approximately 9,600 students: 37 percent in undergraduate programs and the balance in graduate and professional programs.

On March 2, the CWRU Board of Trustees approved a $25M long-term agreement, or Integrated Technology Partnership (ITP), with Sprint and an alliance of world-class technology vendors, including Cisco Systems, Inc. In accordance with this ITP, Sprint and Cisco will implement gigabit switched Ethernet to the desktop and introduce a new, campuswide plan for wireless technology to support mobile network access. Sprint spokesperson Mark Brunn, general manager of sales and service, adds, “Sprint has entered into this relationship not just as a vendor but as a partner that will continue to provide innovative solutions over the five-year life of the initial ITP and beyond.”

For CWRU, this ITP represents a giant leap toward achieving its vision of electronic learning. Originally developed in the 1980s, this vision has at its core an information appliance that combines a computer, telephone, and television all in one and appears in every classroom and on every desktop. This appliance would enhance the efficiency and richness of the learning experience by allowing students to interact with each other, with their instructors, and with sources of information through multiple data, voice, and video channels.

Though this visionary appliance does not yet exist, according to Lev Gonick, vice president of information systems, the new switched gig-to-the-desktop LAN goes a long way toward eliminating any network roadblocks to the high-definition 3-D modeling, desktop videoconferencing, and engineering simulation that would be part of its implementation. As Gonick explains, “Previously, one of the primary instructional functions was to synthesize information so that it could be delivered efficiently. Now that not only information but also virtual reality can be delivered efficiently, instructors can spend more time engaging with students in the art of discovery.”

CWRU has a reputation for putting leading-edge technology to use in innovative ways. Indeed, the gigabit-to-the-desktop LAN is simply the latest step in an evolution of learning and teaching that spans several decades. For example, in 1989, the University began wiring the campus with fiber not just in the core, but all the way to each and every desktop and every residence-hall pillow. In the following years, the vision continued as fiber was deployed to the desktop first in the academic and then...
administrative buildings. CWRU led the way in the development of its allfiber-optic computer network. This network was then linked to 45 affiliated arts and educational institutions known collectively as Cleveland's University Circle.

**Electronic Learning and Student Life**

An essential part of CWRU life is the Electronic Learning Environment (ELE), based upon an advanced fiber-optic communication network known as CWRUnet. Daily computer usage is an integral part of campus academic and social activities. CWRUnet unites the entire campus and connects it to the world through the Internet. CWRUnet is also used to provide other services such as telephone and cable television.

Computing at CWRU is not limited to word processing, calculations, and access to the library catalog. Many courses incorporate class bulletin boards and other Web-based resources, multisensory learning tools—such as NetMeeting and streaming video—and discipline-specific software—such as Mathematica, CAD, and Adobe Studio. Library resources include access to the catalog of full-text databases and electronic journals. In addition, the social life of the campus is enhanced through recreational use of the network for computer games, MultiUser Dimension (MUD) cyberspaces, and chat rooms. The Curriculum Support Group is currently maintaining and developing several virtual worlds including Li Chastels de Savance (The Castle of Wisdom), a virtual CWRU campus, and an ancient Greco-Hellenistic theater found in Epidaurus, Greece.

**Technological Teaching Tools**

Academic and research staff make use of a range of electronic technologies to deliver enriched information. In most cases the new gigabit LAN will facilitate the use of these technologies by eliminating any bottlenecks between the data drop point and the remote processor, which in some cases may be a supercomputer located on the Internet2 network. These technologies include the following:

- Virtual Workbench (a.k.a. Dextroscope). The virtual workbench consists of a display system and a graphics workstation (Silicon Graphics) running application software. The display system projects a reflected stereo virtual image that allows the student to reach into a virtual space. Physical tools can manipulate virtual objects in the virtual space in a hand-eye-coordinated manner. For example, medical students can cut or sew virtual tissue, actually “feel” the pressure exerted, and receive a report on how well they did.
- Digitally Enhanced Mannequins. Nurse anesthetists, anesthesiologists, and surgeons improve their skills by training on highly sophisticated, digitally enhanced mannequins that can be programmed to simulate various medical conditions and emergencies.

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• Online learning. A software package from Blackboard, Inc., is used by teaching faculty to develop Web-based instructional materials and integrate them into traditional face-to-face classes.

• Audiovisual Services. The audiovisual center offers a full range of multimedia services over CWRUnet, including video and audio conferencing, satellite downlinking, Webcasting, and 41-channel cable television with three channels reserved for the CWRU community. The fiber-optic LAN serves as a backbone to distribute the amplitude-modulated (AM) audiovisual signal to various hubs around campus.

CWRUnet Today
Currently, CWRUnet is a fiber-optic network using 10/100 Ethernet switches and some legacy asynchronous transfer mode (ATM) equipment. In University housing and throughout campus, desktop computers interface to the CWRUnet network through direct fiber-optic connection points known as faceplates. However, because of the 10/100 Ethernet bandwidth limitation, the potential of this direct fiber-optic network has not yet been fully utilized.

To take advantage of the CWRUnet resources, students must have access to a powerful computer with multimedia capabilities. While students are not required to own a computer, the University encourages them to do so, providing an interest-free loan of up to $2,500 to finance the system. In fact, more than 90 percent of students in recent incoming classes have owned their own computers. High-end business computers are preferred because these are less likely to become obsolete during the course of a four-year program and can be more easily upgraded. Typical recommendations are for a 1.4-GHz processor with minimum 256 MB of RAM.

For off-campus computer users, CWRU currently offers both a free, limited service and a fee-based Enhanced Remote Access package that allows access to most ELE services. All service levels support Serial Line Internet Protocol (SLIP) and Point-to-Point (PPP) connections at speeds up to 56Kbps for V.90 modems. DSL, ISDN, and cable modem connections from client environments are also supported.

The current wireless data system employed in CWRUnet utilizes Cisco 340 and 350 Aironet series access points that are compatible with Wi-Fi (IEEE 802.11b) compliant wireless client interface cards. For security reasons, access points are placed in a private network separate from CWRUnet. Virtual Private Network (VPN) technology provides access to CWRUnet from this private network. Currently, wireless access points are limited to just a few locations on campus.

The fiber-optic infrastructure carries video from the campus video head-end to each distribution hub.

Highlights of the New Gigabit Network
The new gigabit network features the following technological enhancements that improve both delivery of learning content and availability to the wider community:

• Capacity. Eventually servicing approximately 15,000 on- and off-campus connections, the new data network will provide 1 gigabit to the desktop and 10 gigabit for backbone transport.

• Switched Ethernet. To minimize traffic and optimize use of bandwidth, the Ethernet protocol is switched rather than shared. In shared Ethernet, packets are flooded to all destination addresses whether the packets are intended for them or not. In switched Ethernet, packets are switched only to the designated host or LAN segment. Segments are connected by switching hubs, and hosts (usually desktop computers) are connected through a switch rather than a repeater—hence, the expression “switched Ethernet to the desktop.”

• Flexibility. The primary advantage of switched Ethernet is the isolation of traffic on a per-port basis. VLANs are also possible on a switched Ethernet. VLANs are typically used to isolate traffic for the purpose of implementing some policy such as quality of service or preventing access to certain systems for security reasons, and so on.

• Desktop video. The university will install 2,500 desktop video cameras across the campus.

• Integrated wireless infrastructure. A full wireless data network will be
implemented throughout the campus, including the dormitories and public spaces. Wireless technology will no longer be an add-on to the system. As Lev Gonick explains, "The new project enables wireless access as a 'shared layer' of connectivity running on top of the switched gigabit network."

- More video channels. The campus video network will be enhanced to accommodate more than 70 channels of digital video content.
- Community participation. The ITP allows affiliates in the University Circle—including the Cleveland Institute of Art, the Cleveland Institute of Music, and the Cleveland Symphony Orchestra— to buy Sprint services, including LAN electronics, from Sprint at the same discounted prices the University negotiated.
- An epicenter for technological growth. Linking as it does Cleveland Clinic, CWRU, and the University Hospital, the gigabit network will provide an information corridor for technological growth and medical research.

**Project Phases**

CWRU will be purchasing new campus network equipment in various phases over the next 18 months. The Peter B. Lewis Building, which houses the Weatherhead School of Management, will be the first building on campus—and indeed, the first building at any university in the country—to feature the new standard of switched gigabit to the desktop. Residence halls and Greek houses will be upgraded after the Lewis Building, with the technology operational by August. Plans for implementation in other campus facilities will be developed in the coming months, with campuswide completion expected by August 2003 and integration of community partners to follow.

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Upgrade at the University of Minnesota

Two years ago, the main campus telephone system at the University of Minnesota finally came to its day of reckoning. It was 16 years old, and it was clear that it just could not keep up with the growth of the campus and the increasing demands on it.

The main campus, located in Minneapolis and St. Paul, has more than 45,000 students, or about three-fourths of all the students in the entire University of Minnesota system. It is a spread-out campus, straddling the Mississippi River, with a hospital complex and an agricultural campus as well as some campus elements in western Minneapolis. Before the upgrade, this main campus was served by three separate Intecom S80 systems. The goal was to create a single, easily manageable system.

Actually, the University was fortunate because the three systems were operating reliably. Repair parts were becoming hard to find, and Intecom's support for this system ends in 2003. The University had hit the ceiling on the number of users and because the system was mid-1980s vintage, it didn't offer CLASS features such as caller ID, last call return, and distinctive ringing.

Looking Back to 1984

A little bit of history will help illustrate how the University of Minnesota got to where it is today. It originally chose the Intecom S80 PBX because it was the first digital system that integrated voice and data. To overcome distance limitations of the system on the large campus, the system was set up as three separate but networked telephone switches. The entire campus was rewired at the time with new twisted-pair copper wire.

Fortunately, the University thought strategically and put down a core infrastructure of fiber-optic cable. Over the years, this physical plant infrastructure had always been well maintained, which helped accomplish an upgrade without any significant cabling cost.

As the University grew and technology advanced, time eventually caught up with the telephone system, and it was nearly at capacity in total number of directory numbers. Replacement parts were no longer manufactured, forcing searches on the secondary market and even purchases of old systems from other users to maintain the system.

The system's limitations relative to 21st-century telecommunications needs became much more obvious. The hardware was not as fault-tolerant as present day systems. The University's system was also incapable of handling massive call volumes in times of emergency. At such times, some calls were dropped to keep the entire system from failing.
New System Wish List
In an upgrade, the University was looking for a system with a single database. The old system was split into three separate databases, which meant that technical staff had to work in all three of them at the same time to make sure that services were built correctly and were effectively synchronized. Clearly, this complicated daily operations and added unnecessary labor expenses.

The University wanted a system with a smaller footprint and lower power requirements. Several equipment rooms were practically bursting at the seams, and the old system took up approximately 1,000 square feet. It was requiring more than 400 kilowatts of electrical power per hour, and throwing off a considerable amount of heat—an output of 1.24 million BTUs per hour.

The University's office of information technology began the upgrade process in 1999 with a competitive RFI in which it compared Intecom's upgrade solution against several other major equipment providers' replacement solutions. It also solicited centrex solutions from two large service providers. Ultimately, the University decided to stick with the current vendor as the most cost-effective choice. This enabled re-use of the cable and distribution center infrastructure, as well as the simplest strategy for managing the change. Total cost of the upgrade was calculated at about half of the $31 million that the University invested in 1985 for the original system.

As the IT staff planned the project, they looked closely at how it would affect the University's business, since this upgrade was to be done in phases over the course of a school year. This was another advantage of staying with the same vendor, because the station equipment required no end-user training and the staff had strong technical skills, having worked for so long with the existing system.

Launching the Upgrade
The upgrade began in 2001, with completion scheduled for the middle of 2002. Intecom's PointSpan™ platform is an IP-enabled system that filled certain basic requirements. They included:

- resolution of the capacity problem;
- decreased space and power requirements;
- simplified maintenance;
- improved service provisioning to customers;
U of M's Phone Decision Paid Off

The University of Minnesota was among the first private organizations to purchase and maintain its own telephone system. The University began analyzing its long-range telecommunications needs in 1981, and as the date grew nearer for the divestiture of the Bell companies at the beginning of 1984, administrators were poised to make their move.

At the time, the University had approximately 16,000 main lines and 2,000 extensions and had been obtaining its services from Northwestern Bell Telephone.

The University Hospital, new at the time, and student residential halls presented major expansion needs and demands for new call-handling features. The substantial cost of station moves and changes, paid on monthly bills, was another headache.

Determined that it could realize major financial savings, the University of Minnesota took over administration of the telephone system and customers. The strategy paid off, and over the last two decades the University has been able to offer and maintain competitive service rates. Customers today pay lower rates than they did in 1985.

At the Core

The core of this new system is a 40,000-port platform. At completion of the project, two main nodes of this system will be located in geographically separate buildings. Those buildings will house PointSpan Enterprise Communication Servers (ECS), which provide the call-processing application, database, and administrative functions of the system. Either server is capable of running the entire 40,000-port system. Locating these two servers in different buildings assures a high degree of disaster recovery capability and fault tolerance.

The ECS servers provide call-processing services for six IP-connected telephony nodes on the campus, which function as circuit-switched clients of the ECS. They communicate with the servers over a redundant IP data network. Two of these nodes are in the same locations as the ECS servers, and the other four are in buildings with large concentrations of users. The latter four locations are also equipped with Node Control Servers, which provide nodal survivability in the event that the node is isolated from the rest of the network. They do not become part of the operation of the network unless the node loses communication to the ECS servers.

Each IP node serves a number of nearby buildings via fiber-distributed shelves, and each is fully non-blocking, internal to the node. Connectivity between the nodes is achieved by using fiber connections with up to 1,100 talk paths each. The University's IP network currently does not carry production voice in any significant volume.

Attacking Equipment Rooms

Each of the equipment-room upgrades presented its own individual challenge, but the IT staff was able to follow a common plan among them. First, they prepared the equipment room and installed the new core equipment, running both systems at the same time until the cutover was successfully completed.

They imposed a database “freeze” while database information was extracted from the old PBX and imported into the upgraded equipment. Cutovers were often timed for Friday nights, and on that night, the old PBX database was modified to route the user's directory numbers to the upgraded system. Technical contractors moved each phone to the new system by moving cross-connect wires in the equipment room. The old PBX cabinets were powered down and will be removed once all services are transitioned.

Once it was clear that the equipment and service were stable, operational control was transferred back to the office of information technology and the database freeze removed. Any additions that were implemented during the freeze were reconciled. Most sites were completed in a single weekend in this manner.

The system upgrade brings many new features:

- Interactive voice card functionality replaced about three relay racks full of ACD recorders, supporting about 200 ACDs.
- Lightweight Directory Access Protocol (LDAP) integration accommodates "add/delete/compare/modify" commands and the time of the activity, either immediate or scheduled, via the LDAP interface.
- E911 allows transmission of the calling-party caller-ID information with a transferred call.
- CLASS feature set allowed the University to implement last-call return and enable and disable caller-ID presentation, distinctive ringing, call forwarding, selective call forwarding, anonymous caller rejection, and call-waiting caller ID.
- Voicemail lights is a small but useful feature that is now supported by all telephone sets.
One major advantage that the system upgrade is giving the University of Minnesota is a common numbering system across the entire campus. With the previous installation, operating off three separate PBX systems, there were three different numbering zones. Now a consistent numbering system operates from a single database.

Clearly, this upgraded system is accomplishing the objectives set for it:

- The University resolved its capacity problems, since the new system has vastly increased directory number limits. The system can complete half a million calls per hour, nearly 10 times more than the old system.
- The new system has a single database and point of entry. There is no longer a need to keep multiple systems synchronized, and the new system can link with on-campus databases. Now a user can be set up in the X.500 database and have the PBX database automatically created at the same time. Directory numbers can be moved from one campus to another, and one telephone number can ring in any number of assigned locations at the same time.
- The upgrade drastically reduced system space and power requirements. The new system, at a total of about 460 square feet, is less than half the footprint of the old system. The University was able to replace cabinets and equipment racks with a fraction of the old number. The new system requires only 48 kilowatts per hour—about one-eighth as much as the old system—and it produces about 175,000 BTUs per hour, or only about 15 percent as much as the old system.
- The system now supports digital phones on a single pair for up to 4,000 feet, where the old system needed two pair for a maximum reach of 2,000 feet. This frees up a significant segment of cable infrastructure and enables delivery of services farther than before.

As the University completes its revamped campus network, it is worth noting that its installation stands as the largest geographically distributed voice architecture system in the United States. A nice distinction, perhaps, but what is more important to the University is the peace of mind that comes with knowing that the system will meet its needs now and into the future.

Charlie Henderson is director of product management for Intecom. He can be contacted at chenderson@intecom.com.
Streaming Video and Video Instant Messaging Delivered Direct to PCs

by Peter F. Daly, Jr.
Lamont Digital Systems, Inc.

Colleges and universities today must juggle two seemingly disparate IT goals. On the one hand, institutions of higher education are expected to be on the cutting edge of technology services and usage. And in the highly competitive race to attract top-caliber students and faculty, a “wired” campus is a strategic advantage. In our information-age economy, developing and honing technology skills is critical to success across all fields. Therefore, students and professors alike actively seek a technology-enhanced academic environment, where access to high-speed data and telecommunications capabilities is ubiquitous across the campus, and multimedia research tools and instructional television are seamlessly integrated into the curricula. Moreover, the availability of a host of communications and entertainment sources in dorm rooms, such as satellite television, is a big “quality of life” issue.

On the other hand, educational institutions of all sizes are facing formidable financial challenges. With an uncertain U.S. economy and its adverse impact on private and public funding sources, colleges and universities are under pressure to streamline and contain IT expenditures. As a result, IT professionals at schools across the country are making hard decisions about the data and telecom services they provide. The bottom line in the decision making is twofold: first and foremost, “What can we afford?” and, running a close second, “What can our systems support?”

Identifying and Meeting the Needs

Most schools have made a sizeable commitment to IT and plan to upgrade their basic infrastructure every few years. However, projecting and planning for the future is difficult given the rates at which Internet, wireless, and broadband technologies are evolving. For the telecom team running a large campus intranet, the user community’s insatiable appetite for more and better connectivity and applications can be as hard to manage as a 1,000-pound great white mechanical shark with teeth. The situation reminds me of the famous promo for Jaws 2: “Just when you thought it was safe to go back in the water....”

The vast majority of campuses today offer basic Internet and e-mail services and cable viewing of some description. Many have upgraded to digital video systems so they can offer satellite and cable service directly to dorm rooms. Yet, even with these bases covered, a host of new technology advances are now commercially available, such as streaming video, video instant messaging (VIM), distance learning, local networking, videoconferencing, and teleconferencing. The question is are they affordable?

The answer is yes. Live television, both satellite and local services, can be streamed over fiber, coax, and hybrid fiber/coax infrastructures. The majority of campus networks are designed with lots of reserve capacity and power. In fact, probably 80 percent of IT backbones at midsized to large universities have the bandwidth already in place to support multicasting, video streaming, VIM, distance learning, videoconferencing, and teleconferencing.

New patented video-streaming and VIM solutions are designed to deliver their services over existing high-speed data and video networks. As a result, campuses can now offer streaming video broadcasts of cable television over data channels directly to students’ personal computers. From a practical perspective this means that all video, audio, multimedia, and high-bandwidth data are delivered to one desktop device. Fewer appliances mean less space is required, less power is consumed, and less clutter is accumulated.

Today’s students are more likely to have a computer than a TV in their dorm rooms. And the new, enhanced IP-based video services do not require expensive, high maintenance converter
boxes—the number one cause of service problems on campuses. And with new video hypercompression technologies, campus e-mail services now can integrate video with text.

For IT directors, there is an added benefit. Centralized services reduce administrative headaches. Consolidated billing, program delivery, and customer support alleviate much of the work involved in operating individual systems.

What are the options if you are considering offering video streaming and VIM technologies?

**Video Streaming**

Most campuses either are aware of or have experience with video streaming applications such as RealMedia, Windows Media, Quicktime, and MPEG. At the next level, we are seeing some new all-software, turnkey solutions that encode, compress, and digitally deliver TV-quality, full-motion video programming that can be both live and pre-recorded. It can be viewed in a window or as a full-screen broadcast and is delivered over a data network to any attached PC. The client viewer is a single version of application-served software delivered to the desktop device when a video is requested. This enables the IT department to have total control of versioning and usage.

In a multitasking society, the luxury of having multiple, mixed-media information sources at one’s fingertips is a big selling point for living on campus instead of renting an apartment off campus. For example, while writing a term paper or researching on the Web, the student can keep an eye on a live NCAA college basketball game in a corner window of the screen. And since converter boxes are not needed, the service is truly mobile; students and faculty members can call up video streams from any “wired” location on campus—dormitories, libraries, classrooms, recreation areas and computer labs—using an attached PC or laptop.

With video streaming available both live and “on tap,” schools can support a media-rich gamut of broadcast news, education, and entertainment options over their data network. This opens the door to distance learning (i.e., both simulcast and archived classes and lectures), video training and conferencing, and foreign language programming (i.e., SCOLA and International Channel). The low-cost video capabilities also can be tapped to upgrade campus security (i.e., video monitoring surveillance).

By way of example, here’s how the CampuStream.TV system from Campus TeleVideo works. A standard analog video/audio signal is captured, and the uncompressed raw data is digitally encoded into an MPEG-2-compliant format at bit rates configurable from 300 Kbps to 2 Mbps. The video content is encapsulated using User Datagram Protocol (UDP), Transmission Control Protocol (TCP), or Hypertext Transfer Protocol (HTTP) transmission protocols. The video is broadcast using IP for delivery over an IP-based broadband network. Video resolution is TV-quality, full-motion at 320 x 240 pixels with a frame rate of 30 frames per second. A playback feature supports the archival storage of pre-encoded video streams for future viewing. The storage requirements are relatively low. For instance, a one-hour video encoded at a bit rate of 800 Kbps will require approximately 360 MB of disk storage.

The software can operate over any multicast-enabled IP network. Multicasting enables the efficient, low-cost

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deployment of multimedia applications on a data network by minimizing bandwidth requirements. With this onetomany delivery model, a single copy of the data is available, on demand, to any and all clients that request it. With standard video transmissions, 500 clients receiving a 1-Mbps video stream would require 500 Mbps of bandwidth. With an IP multicast, the 500 clients are served the same 1-Mbps video stream simultaneously, so only 1 Mbps of bandwidth is required. Moreover, a single IP multicast video stream can service hundreds, if not thousands, of users. The software supports varied client systems, such as Microsoft Windows, Linux, or Mac OS.

When programming is requested, the software determines the operating environment of the client PC and automatically downloads the most current and applicable thin client. The client viewer is extremely thin, approximately 200 Kb. Due to this small footprint, a single version of application-served software is transparently delivered to the client from the server. With this solution, a patentpending technology eliminates the need for local storage of any client application. The client resides in RAM and disappears after the user ends the session. This eliminates the need for the user to download, install, and maintain a large media player. Moreover, there are no plug-ins to install or PC-based application software for the IS staff to upgrade or maintain. The small footprint will support future IP-enabled devices, such as mobile phones, PDAs, and other wireless and wired devices.

Because the program stream is a standalone, runtime-executable file, the quality of the broadcast is not tied to the Web browser’s performance. In fact, the browser functions as a remote control: select programming from a menu and the browser initiates the automatic player download process. Once the video stream has been downloaded, the user is free to close or minimize the browser or surf to another Internet destination.

The network topography for a medium- to large-scale deployment typically consists of a routed network with clients and servers on different subnets. If the router is configured to support IP multicast, then the clients on all the subnets will be able to receive the multicast video streams. If, however, an older router doesn’t support IP multicast, then only the clients on the local subnet will be able to receive the streams. To allow clients from the other subnets to receive the service, unicast redistribution and bridging server technologies convert multicast IP streams into unicast IP streams. This allows the system to be used on nonmulticast-enabled networks as well as through firewall devices. The process is similar to transforming digital data/voice signals to analog for delivery via POTS lines into the home. In this case, the software converts the original multicast UPD to a unicast UDP for network transmission, and then converts it back to multicast UDP for client reception.

**Video Instant Messaging**

Another “hot” telecom development is VIM. By bringing the dimension of video to IP-driven communications, student and faculty groups can engage in one-on-one or group video chats.

As part of this new service, a new patented video compression technology uses instant messaging technology and IP-based services to compress video images by 75–87 percent before encoding. As a result of this hypercompression, video data can be manipulated just as with traditional text-based applications. With bandwidth requirements reduced by up to 75 percent, VIM can use standard DSL, cable, and 3G networks for both downstream and upstream transmission. The IP-based technology supports one-to-one or one-to-many conversations (group chat), which can be archived and replayed. The software dynamically adjusts the video data to the client’s hardware profile to provide the highest viewing experience.

Storage also is reduced by 75 percent or more. Only one version of the media is required for storage, and the same data source can serve a range of devices, including PCs, PDAs, and cell phones.

Being on the cutting edge of today’s technology doesn’t have to be a budget-buster. With flexible financing options available, making an investment in the services you provide to faculty, staff, and students makes strategic sense. If a campus is going to attract bright students whose lifestyles are technology-based and who have high expectations from IT, it must consider the services that are increasingly important in choosing a college.

Peter F. Daly, Jr. is cofounder and chief technology officer of Lamont Digital Systems, Inc. Pete can be reached via e-mail at pdaly@campus televideo.com. Campus TeleVideo, a division of Lamont Digital Systems, Inc., is headquartered in Greenwich, Conn.
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The Metaverse at the University of Kentucky

by Bill Robinson & Alicia P. Gregory

Will higher education be relevant in five years? John Chambers of Cisco Systems posed that question in 1999.

Now, three years later, as their Metaverse turns videoconferencing into virtual reality, it seems the University of Kentucky (UK) is ready to answer a resounding Yes!

Back to the Future

Among those who heard Chambers’ question was ACUTA member Doyle Friskney, associate vice president for information systems at the University of Kentucky. In 1999 UK was very much a forward-looking institution with ambitions of becoming a top-20 research campus. Its 622-Mbps asynchronous transfer mode (ATM) campus backbone installed in 1996 was already paying dividends beyond what could have been foreseen at its inception.

But Friskney and his colleagues in both administration and academics realized that Chambers was pointing to an even more challenging future that was arriving faster than almost anyone realized.

For institutions of higher learning, industry was poised to ask some hard questions: Where will a firm such as Cisco find the network engineers and technicians it will require for the next cycle of cyber development? Who will create the applications that will enhance corporate productivity and fuel global prosperity? Where will today’s technology innovators obtain the advanced training they will need to take them to the next level?

Now, two years ahead of Chambers’ rhetorical deadline, teams of UK students and researchers are using the University’s gigabit networking capabilities to develop as well as employ the applications that will enable higher education to meet the demanding expectations of its clients.

Out of the CAVE

Walk into the prototype classroom in UK’s Center for Networking Excellence and you will see a wall of video. Look more closely and you will notice that the life-size images portrayed are not emanating from rear-projection television monitors. Optic projectors suspended from the ceiling cast these lifelike figures on the flat wall surface. And just as a wall-size mirror mimics reality and appears to double the size of a room, these projected images seem to add blocks of space to the classroom in each direction. Unlike mirror images, however, these images can originate from a location across campus, from another campus across the state, or even from an offshore campus such as the University of Puerto Rico.

The challenge issued by Cisco’s Chambers helped draw UK out of the CAVE, so to speak, expanding its horizons toward a new paradigm known as the Metaverse. CAVE, or Cave Automatic Virtual Environment, is probably the predominant form of large-scale, high-resolution video. It recreates reality by surrounding the viewer with rear-projection TV screens, greatly enhancing videoconferencing and distance learning. But CAVE technology has two big handicaps: cost and complexity. Large rear-projection displays are not only expensive to purchase, they are difficult to maintain. If synchronization is lost, only trained
UK’s new mechanical engineering building will be home to the campus’s second Metaverse classroom. A third will be housed in the University’s showplace William T. Young Library, while the fourth will be set up in the Computational Sciences Building. Yet another will be located, improbable as it may sound, at the University of Puerto Rico (UPR). Metaverses at UK and UPR would be linked by Internet2 and would allow the two universities to intensify the collaborative research effort which they began in 1998. After that link is set up, UK professors, such as Seales and Jaynes, who both have taught courses on site in Puerto Rico, can teach UPR students from their facilities in Lexington. Ten UPR undergrads studied in Kentucky during the past year, five of them in computer science.

Better Than a Lab
Professor Jim McDonough plans to utilize the Metaverse to teach a course in fluid dynamics after a classroom is setup in UK’s mechanical engineering building. “Fluid dynamics is typically one of the more difficult areas for undergrads to comprehend, and most of us who teach it feel it would be valuable to provide laboratory demonstrations during lectures, possibly as part of every lecture. But this isn’t feasible; it’s too expensive, too time consuming, and in some cases, even dangerous. We believe the Metaverse will provide us with a tool that will allow easy, inexpensive display of the same things that a laboratory experiment would give us.”

“Most of us who do computational fluid dynamics have recognized for years that as computing power permits us to solve increasingly more difficult problems, we’ll need better ways to analyze and understand computed results, simply because we’ll be getting more data from a simulation,” says McDonough. “Just as we have moved
from leafing through piles of computer paper output in the 1980s to flat-screen scientific visualization in the 1990s, we are confident that we must now move to fully immersive, interactive, 3-D methods to be able to understand what the results of a simulation are telling us. The Metaverse will provide such capability at a reasonable cost."

And, thanks to the Metaverse and Internet2, students at UPR may get to sit in on McDonough’s classes.

The effectiveness of the Metaverse as a teaching tool will be evaluated by Professor Joan Mazur of UK’s College of Education, who, along with a student team, will monitor the proceedings and outcomes of courses such as McDonough’s. Like the Metaverse project itself, Mazur’s effort is being funded by a grant from the National Science Foundation.

High-Bandwidth Applications

The Metaverse did not spring up spontaneously from the bluegrass growing on UK’s campus. It is a logical progression from the University’s investment in infrastructure and early participation in a previous form of advanced, long-distance video, the Access Grid, as well as being part of Internet2 and the Southern University Research Association WAN. Developed by the National Center for Supercomputing Applications (NCSA), Access Grids provide a large-scale multimedia link between the computational science programs for about 40 allied institutions. UK was an early adopter of this application, and UK’s computational science faculty regularly participate in professional conferences and other exchanges using Access Grid.

An Access Grid display, such as you will find in UK’s computational science building, requires about 5 MB per video screen, and it runs on concurrent video screens. "If you have six sites broadcasting to each other, they don’t run concurrently; they run on separate streams, so you can find yourself looking for 30 megabits of bandwidth," says Friskney. That’s a long way from the 384kb required to transport H.323 video.

"The Metaverse introduces some very difficult networking problems," comments Jim Griffioen, director of the Center for Advanced Networking at UK. "The amount of visual information generated by the Metaverse is massive, and even today’s high-speed networks are largely incapable of delivering this type of data back and forth."

The solution to that problem will come when four campus locations are connected by a 10-gigabit backbone. NSF, whose support has helped make Metaverse research and development possible, is also providing funds to install this next-level transport. But connection isn’t simply infrastructure.

"If you want to go to the next level, where you’re sending information back and forth to other Metaverse sites," adds Seales, "you’re looking at a wide-area network. I understand the data and algorithmic requirements, but the transport is beyond me, so it’s absolutely critical that we’re collaborating with network experts."

Griffioen credits the collaboration between LAN researchers and network administrators whose offices are on different floors of the same building as vital to the future of the Metaverse. "Having the people who manage real networks so close by has been very beneficial," he says. "They are able to provide insight into problems we might encounter as we deploy these futuristic environments."

"Working with Doyle Friskney and others in charge of UK’s networking infrastructure gives us unique access to the campus network as an experimental network," says Jaynes, who points out that this kind of collaboration was one of the reasons he was drawn to UK. "I was looking for an environment that would allow me to incubate ideas in the presence of other people, and the networking people here are very valuable to me in that regard."

The need for high-speed transfer of digital images for UK’s medical college and hospital gave impetus to previous upgrades of the University’s installation of networking infrastructure, and it continues to do so. A 10-year, $70M project to create an online, integrated patient record system is underway. In addition to text, this system will make diagnostic images readily available to physicians.

Some Important Steps at UK Today

The current gigabit Ethernet backbone supports development of next-generation videoconferencing, distance learning, and high-resolution imaging. At the same time, it is also making possible some day-to-day advances that are important but perhaps not as exciting as the Metaverse, such as migration from H.320 to H.323 video and IP voice communication.

Friskney characterizes H.323 video as "teleconferencing on the network." While an H.320 video-equipped classroom can cost from $125,000 to $170,000, an H.323 classroom for approximately 10 students can be set up for 60 percent of that cost. "The savings are substantial and the quality is there," he adds. Graduate seminars, which generally consist of 10 to 12 students, can usually make the best use of video teleconferencing, Friskney points out.

Polycom equipment has proven cost efficient for UK in the migration from H.320 to H.323, Friskney continues. "Polycom was probably the leader in developing H.323 with the same quality you’d find in the H.320 room-based systems." Most of UK’s H.320 equipment was Vtel.

UK’s campus network carries voice as well as video. Four campus structures, including the main administration building, currently employ voice over IP, using Cisco Avvid technology. Voice over IP should be installed in three other campus buildings by the time classes resume in late August.
As robust as a gigabit backbone is, bandwidth remains a precious commodity. Using the backbone or even traditional phone wires for applications that don’t require them is a waste of resources. Accordingly, UK is diverting transport for applications with less-demanding data flow to wireless.

“When we installed the ATM network, joined the NSF’s Southeastern Universities Research Association network, and then joined Internet2, we developed expertise in areas that have paid off in ways we never could have imagined,” Friskney says reflectively. “Who could have predicted that our efforts would result in academic/administrative partnerships that would be developing such futuristic applications as the Metaverse?”

Some important steps have been and are being taken as a state-of-the-art telecommunications environment emerges on the UK campus. To answer Chambers’ question, UK appears to be saying Yes, higher education will always be relevant; but how content is delivered and resources are accessed may make the educational journey more exciting as well as meaningful.

Bill Robinson is a freelance writer who lives in Richmond, Kentucky. Formerly the publications editor at ACUTA, Bill is a frequent contributor to the journal. He can be reached at r_bill_2000@yahoo.com.

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University of Idaho: Wired for Efficiency

University of Idaho, one of Yahoo! Internet magazine’s Most Wired Campuses, keeps operating budgets in check while increasing productivity through advanced networking technologies. The school has established strategic goals in the areas of education, research, and community outreach.

The Challenge
To achieve its goals, in 1993 the University committed to a Computing and Connectivity Plan aimed at delivering required advanced information technologies by 1998. "The strategic use of technology and exploitation of today’s IT revolution drive the education, research, and outreach goals we’ve set forth for this institution," says Bob Hoover, president of the University of Idaho. "To be the residential campus of choice for students in the Northwest and West, we must provide a superior educational experience and prepare students for the e-world."

The University needed to develop a communications infrastructure to support distributed information management. "We wanted to create a networking environment that would enable everyone to do all their work from the desktop, and meet every user expectation at the desktop," states Jerry Wallace, vice president of finance at the University of Idaho.

The scientific community’s networking requirements also needed to be addressed. The University’s Advantage Idaho is a multiyear, $64M research partnership with Idaho businesses, government, industry, and Idaho’s research university. Advantage Idaho focuses on the areas of food and fiber production and molecular biology; environmental sciences and technology; materials science; and infrastructure, construction, and transportation. Highly collaborative and bandwidth-intensive, these initiatives demand nothing less than robust and completely reliable networking capabilities.

In 1999 the bar was raised even higher for the University when Yahoo! ranked it the 13th Most Wired Campus out of 571 schools in the United States.

"Bringing a campus of our size to a wired standard is a huge undertaking," explains Harvey Hughett, executive director of Information Technology Services. "Such an undertaking is much easier for a smaller school that has fewer connections and can move faster. So the Yahoo! ranking was a significant distinction for this institution. We wanted to maintain and advance our Most Wired Campus status, and we sourced vendors with whom we could partner to achieve not only this goal but all the goals set forth by the institution."

The Solution
"We sat with four major vendors to determine who could best bring this institution into the next millennium," explains Hughett. Issues of network migration, compatibility with existing computing solutions, scalability, bandwidth capacity, actual throughput, reliability, and redundancy were key considerations for the University. "We were looking for someone who understood education," continues Hughett. "Cisco was the leader from a technology perspective with a demonstrated commitment to advancing the goals of higher education through advanced networking solutions."
Upgrading the Backbone
The Cisco solution upgraded the University's network backbone to 4-Gb capacity with Gigabit EtherChannel® technology incorporated in Cisco Catalyst® 6500 and 5500 series switches. Existing Cisco 5000 series switches and Cisco 7500 series routers were redeployed strategically throughout the network.

“We standardized on Cisco technology for several reasons,” notes Hughett. “While the university capitalizes on the inherent training benefits of a single-vendor solution, Cisco was able to deliver more bandwidth at a lower cost because Cisco more efficiently used the existing network install base, and this allowed us to multiply by at least 10 the amount of bandwidth available for distribution.”

Cisco also provided the software management tools that enabled the University to expand and scale its network. “With Cisco we needed fewer switches and routers, which optimized space utilization in wiring closets,” notes Hughett.

Impacts
• Campus Is Better Served
With a 4-Gb backbone, the University of Idaho has one of the fastest networks in the nation. The University’s WAN connects to 50 educational and service sites in 42 of Idaho’s 44 counties. One hundred percent of dorm rooms and Greek houses have at least 10-Mb connectivity and 100 percent of classrooms are wired to the network. More than 700 computers are available in open-access student labs. Some 24,820 Web pages are served daily. Network traffic has increased 30 percent since 1998, data ports number more than 8,000, and up to 330,000 e-mails are processed daily.

More importantly, this high level of activity reflects a number of network-enabled applications.
• Research Is Advanced
The University’s Center for Secure and Dependable Software (CSDS) is one of seven centers in the country for software security. CSDS is a test bed for software security and safeguards against cyber threats. For example, it develops and experiments with intrusion-detection systems. These systems float on various University processors as well as processors on the Internet. “We’re building virtual networks on campus to test some of our ideas in real practice,” explains Dr. David Thompson, dean of the College of Engineering. “There are times when we need to turn off our campus access so that we don’t infect the campus or other networks around the nation.

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The University is also proposing an interactive computer graphics infrastructure for the state of Idaho and is seeking funding from the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCOR). The initiative will enable the University to deliver academic courses over the network to students throughout the state and will faculty to interact with students in real time. "We have high hopes for EPSCOR funding because interactive computer graphics capabilities do not exist in Idaho," commented Thompson. "We have a good proposal to remedy that situation and the network to support it."

- Outreach Is Strengthened

"Our network is instrumental in giving residents in both rural and developed communities access to the same resources," notes Glenn Wilde, vice provost of outreach and technology. "The key is not to move faculty around the state but to move courses around the state that originate from wherever a faculty member may reside.

"Outreach efforts are helping to maintain the viability of rural communities and agricultural economies," says Wilde. For example, University of Idaho’s outreach services train small businesses in using the Web for e-commerce and provide training and certificate programs such as Ornamental Horticulture and Landscaping.

"Our geographic information systems (GIS) allow county agents, farmers, and ranchers to access material that assists in precision farming," explains Wilde. "When farmers can access satellite images of drainage and rights-of-way, they can plan and grow crops more effectively—and this is all facilitated by the network."

- Communications Enhanced with Campus Pipeline

Communication among students, faculty, staff, and alumni is significantly enhanced through the University’s Campus Pipeline portal. Campus Pipeline is a personalized Web interface that provides 24-hour access to the University of Idaho campus resources and information. It links all members of the University community to one another and to the information they need. "We want students in Idaho Falls to experience academic life just as if they were sitting here in Moscow," says Wallace, "and Campus Pipeline is a point-and-click tool that provides a gateway to our community."

The University Registrar’s Office is capitalizing on advanced management information systems (MIS) that have been enabled by the network. Student records, grades, and course registrations are now available online. Students can search for courses, class schedules, and favorite faculty to develop a program that meets their needs, and faculty can handle all administrative tasks online in an efficient, timely, and accurate manner. Degree audit capabilities allow students to evaluate where they are in relation to graduation requirements for all degree programs.

- Improved Cost Management

While the network is supporting new initiatives in education, research, and outreach, it also promotes enhanced business operations. Costs are better managed as the University’s MIS now runs programs that help to control current expenditures while managing future operating costs. "We’re running an electronic records managements systems that enables us to better manage how records are recorded, processed, and stored," explains Wallace. "Having built intelligence into the system, we’ve effectively reduced errors that commonly occur with manual record keeping."

The University is quickly adopting e-business strategies that promise to generate new revenues. For example, when students sign up for classes, the system knows what books are required for selected classes. Students are then updated on availability of books in the campus bookstore and they can order books online and have them delivered to their rooms.

"We’re going full tilt on e-business," says Wallace, "and as we look to the future our e-businesses will include not only bookstore operations but library services, food service, photocopying, parking permits, and online events ticketing."

Successes generated by a 4 Gb backbone are driving an anticipated upgrade to 10 Gb. This powerful capacity will bring advanced distributed learning programs; Web-assisted tutorials to reduce failure rates, improve outcomes, and increase productivity; voice over IP; streaming video and sound; virtual reality; and new e-learning methodologies.

While network speeds and capacity provide a competitive edge in today’s e-world, University officials such as Glenn Wilde underscore, "This isn’t about the fastest network or most up-to-date technologies. We want to demonstrate how these networking technologies enhance teaching, learning, research, and outreach. We are using these technologies to create a level playing field for all students. We want to enable access to information that is designed, developed, modified, and continuously updated. And, we want to create an educational environment in which there is continued discovery for both faculty and students."

Chuck Lanham is associate director of Information Technology Services at the University of Idaho. He can be reached at clanham@uidaho.edu.
Blaine A. Brownell, president of Ball State University in Muncie, Indiana, has held a number of academic posts at The University of Memphis, the University of North Texas in Denton, and the University of Alabama at Birmingham. He holds M.A. and Ph.D. degrees in United States history from the University of North Carolina at Chapel Hill, and a B.A. degree from Washington and Lee University in Lexington, Virginia. An authority in urban history and the history of the American South, he is author or co-author of seven books and 22 articles or book chapters and has made 60 presentations at professional meetings or other forums around the world.

Bill Brichta is chief technology officer at DeSales University. As an ACUTA director-at-large, he serves as the board advocate for the publications committee.

Brichta: Public institutions throughout the U.S. are facing cutbacks in state funding that are causing some institutions to make major cuts in planned capital and operating expenditures. Do you foresee these financial constraints as long term or short term, and do you believe they will affect the institution's ability to make strategic technology investments? Do you envision ways in which the use of technology in teaching, research, or administration can improve the cost-effective delivery of services?

Brownell: In Indiana, as in most of the rest of the United States, fiscal difficulties are a current fact of life. But difficulties like these are not entirely new to those of us who have been in higher education for some time. I don't think our current fiscal circumstances are a long-term situation. I see these budgetary constraints as tied to the economic downturn, and I believe the economy will rebound. Certainly that's my hope—that we will return to more normal levels of state support for higher education.

In terms of strategic technology investment, I think it's simply going to get more and more challenging because technology is moving so rapidly. Even with what might be considered adequate funding, making the right choices in the areas of technology and communications is challenging because it's very difficult to envision what the next big technological breakthrough is going to be and how it will change the whole nature of our infrastructure. We're always headed into an uncertain future, which makes it exciting as well as a little frustrating. Institutions of higher education are major consumers and often also producers of technology and technology-related products. The concern then is to be looking constantly at all of the pieces of the technology infrastructure—how they relate to each other and how they fit into the broader picture (which is now global)—and to try to make the best possible decisions as we move ahead, knowing all the while that we'll never have adequate resources, no matter how good the funding is, to do everything that we'd like to do.

Brichta: That certainly seems to be one of the challenges—the candle, if you will, being burned on both ends. Students, in particular, are very demanding consumers. They want a whole lot more than the previous user group, and they want it for a whole lot less. It's almost impossible to satisfy both sides of that candle.

Brownell: There's an irony here in that technological innovations are truly labor saving devices that can enhance productivity, and they also create many new possibilities and demands. Let's look at processing power. As the first personal computers saved us time and made us more productive, prices began to drop. But people created new ways to use this computing power that they
simply wouldn't have attempted before they had the new capacity. This
spawned greater expectations, with demands for more powerful processors
and even higher productivity. Every
amazing solution seems to create new
challenges and higher expectations. You
always feel like you're just behind the
last curve and trying to get into the
next one.

Brichata: What challenges do chancel-
ors, presidents, and other senior
leaders face in developing and selling
campus constituents on the strategic
importance of campus networks to
teaching, learning, and research? What
is your vision of the future campus
environment at Ball State? If we want
to take the Internet, and ultimately, the
U.S. economy to the next level as it
relates to e-business, e-learning, e-
government, e-health, etc., what are the
major hurdles to be overcome?

Brownell: I don't really have any
difficulty communicating to any of our
principal constituencies the impor-
tance of technology and our connec-
tion to the Internet as it relates to
teaching, learning, and research. Ball
State was one of the first universities to
wire the entire campus with fiber optics
and connect classrooms to central
multimedia sources so that faculty
members could call up these teaching
enhancements for their courses. It was
a remarkable project and resulted in
some national recognition for Ball
State. As a result of that, our constitu-
encies, though they may not under-
stand all the details, clearly understand
that technology and communications
networks are vitally important to the
university's future.

Like so many other universities, we
have identified the innovative use of
technology as essential to advancing
our mission and it is a specific goal in
our strategic plan—and we are
constantly talking about it.

To be successful, the future campus
environment at Ball State must be rich
in technology. One important point I
try to make, one that I find many
people have not thought much about,
is that there is not a pecking order of
institutions where you're supposed to
have this much bandwidth at a research
university and this much bandwidth at
a comprehensive university. Although
we are not MIT or Cal Tech or even
Purdue, the fact of the matter is that all
universities are under similar pressure
to provide effective and flexible
technology infrastructure and net-
works, at a high level of sophistication,
to students and faculty, whatever our
mission or size.

All institutions are affected by our
migration into the digital age and we're
often finding that our structures and
our definitions don't accommodate the
new realities. Distance education, for
example, used to mean something
delivered to specific, identifiable sites.
The Web has changed the paradigm
and put us all into one huge network.
Even our governing bodies—the
regional accrediting associations and
state commissions of higher educa-
tion—are simply trying to cope with all
the changes that have occurred in
distance education and in even defining
what constitutes distance education.
Ball State has not made a major
commitment to distance education, yet
we have a nursing degree that is offered
entirely online, and we're moving
several other degree programs in that
direction. And a very large number of
our courses make significant use of the
Internet even though they are primarily
on-campus courses.

I think the biggest hurdle for all of
us is maintaining the energy to
constantly look forward. No one seems
to be skeptical about why we need
technology in order to do a good job as
an educational institution: however, I
do struggle somewhat to get people to
think about the next challenge rather
than the previous one.

Brichata: Do you have a vision of the
future campus at Ball State? Look down
the road ten years, what do you see
happening?

Brownell: I learned long ago that when
it comes to technology, ten years is like
the next century. I think three or four
years is as far as we can look ahead. We
are in the process of creating an
entirely wireless networked environ-
ment and making it available to people
on campus. I suppose that the burden
of proof would be on anybody who
would suggest that wireless is not the
wave of the future based on what we
can see now. But it is just another form
of connectivity, albeit perhaps the most
flexible form. I think the Internet and
its successors and the whole concept of
connectivity are still going to be
preeminent in determining the shape
of the future campus learning environ-
ment. We don't know exactly what all
those parameters will be, but it's going
to be faster, more interactive, and more
flexible. We plan to be part of that. We
want our academic programs to be
actively involved in contributing to this
revolution, and we want all of our
programs to take full advantage of
opportunities that these innovations
will provide.

Brichata: Although broadband services
are estimated to be available to over 70
percent of U.S. households and are said
to be redefining how we work and play,
usage rates continue to be relatively low
at less than 12 percent. What are your
views on the strategic importance of
broadband services? What are the
major reasons for this lack of consumer
demand and what "killer applications"
would spur greater usage rates?

Brownell: Very good question, and it is
a little curious that we have all this
capacity and a relatively small percent-
age of people taking advantage of it. I
was taken aback to learn what a low percentage of people filed their tax returns electronically given how easy it is with all the software packages that are out there, and given the fact that you get your refund back more quickly.

In any case, like many other universities, we are working with our local community to try to create a much richer broadband environment all around the institution with the notion that this will enhance our ability to do things as well as to deliver services and programs to the community. I believe entertainment-related products will play a major role in increasing broadband usage because they will interest more people. When a medium is developed where television, streaming video, educational products, and other forms of mass entertainment are controlled from one source, I believe usage will rise dramatically.

Ball State received a $20 million grant from The Lilly Endowment for what we call “The iCommunication Project.” The “i” has many meanings, including “individual,” “interactive,” and “international.” The project is dedicated to exploring the content elements of the new digital universe and the possibilities created by Disney, Time Warner, AOL, Microsoft and, in general, the confluence of entertainment and information. One of the underlying assumptions is that when entertainment and information become even more entwined, there will be synergies that we don’t yet envision. Our iCommunication project is designed to foster ideas in the anticipation that those unrealized synergies will become reality through our research.

Brichta: The Cyber Security Research and Development Act authorized over $800 million over the next five years for cyber security research and development to improve homeland security and vulnerability assessment. What programs and areas of research at Ball State may be supportive of this new funding initiative to improve homeland security and vulnerability assessment?

Brownell: There are aspects of the iCommunication project I just described that would have some bearing on these issues, but it is not primarily directed at them. Any time you talk about content and delivering products in this new environment, you also have to be concerned about intellectual property rights and other related issues. We have faculty here who are working on software reliability,
which is, at one level, simply making sure that the software operates correctly by working out all the bugs. But it also relates to issues of vulnerability to outside interference. This is going to be a huge industry in the future because it’s almost a mirror of our society as a whole. Our society is benefiting from the enormous creative spark that you get from having an open, transparent, connected, and flexible system. But all those characteristics taken together also make us vulnerable to people who have bad motives and wish to bring the system down. I don’t want to make an unnecessary comparison to the 9/11 attacks and the insights we’ve derived from them, but I think our communications and technology networks are now being examined in light of those events.

**Brichta:** Certainly what we’ve seen with the creation of viruses and people sending these things out there just because they can, we have to use some common sense. You’re right on the mark when you say that other things come along with the good things.

**Brownell:** That’s true. I would like to think that we would reach a point in time when all of these problems will be solved. But I’m afraid that all we do when we solve one problem is create challenges with others, so this will be an ongoing struggle for all of us.

**Brichta:** Passage of the U.S. Patriot Act expanding law enforcement powers will likely have an impact on colleges’ and universities’ ability to access and use information content. What policy issues will this impact at Ball State? As a public university, how do we balance the dilemma of being a good citizen while ensuring that the academy remains a forum for expression, debate, and learning?

**Brownell:** I think we have tried not to directly confront all of the issues and implications of this question, and for good reason. There are some gray areas here that are very difficult to penetrate and sort out even at the most prosaic level, such as the expectation that employees at a state university will use their state-owned communications equipment and computers only for state business. It’s very difficult to say that that’s not a reasonable expectation or that we don’t really care whether they do or not. On the other hand, we all realize that one of the characteristics of the new communications environment is that the lines are blurred between one’s working life and private life since networking and friendships and far-flung communication is very much connected to the conduct of business, particularly to creative work.

Like most institutions, we have a basic policy in place; but we are not applying this policy with a heavy hand. However, it’s clear that if someone engages in illegal activity, if they are using University equipment for gambling or for operating a private business, this should not be sanctioned. But to expect the University to create a system of surveillance to ensure that nothing ever goes wrong would unquestionably have a chilling effect on the kind of free expression, interaction, and interchange that are critical elements of the university environment. These are questions that we are going to have to confront when specific cases arise. I would hope that people in law enforcement and those who are trying to seek information from universities will work with us to ensure that we can target those needs and interests and not undermine the academic integrity of the institution.

**Brichta:** The higher education community and society have witnessed significant gain in leveraging IT over the last 25 years. What new and innovative projects and endeavors has Ball State implemented that you are most proud of?

**Brownell:** As a consequence of the fiber-optic wiring of the campus at a relatively early date and the development of this infrastructure specifically for the support of instruction, we developed a fairly large number of faculty who are comfortable using technology and who have now been involved for some time in using technology to enhance teaching and learning. While some of the early uses were probably fairly basic, this experience has had a profound and lasting impact on the way technology is regarded at Ball State. What has emerged is a campus culture in which technology is respected and welcomed, but in which it is regarded as a tool rather than an end in itself. So while we strive to keep up with the latest technology tools and techniques, I truly believe the best thing we have in our technological infrastructure is the awareness among our faculty of how important it is and how it can best be used.

When you’re dealing with challenges and opportunities at this level, you are constantly aware that you have many peers out there who are going through these same experiences in one way or another, and we can all learn from each other. No matter what decisions we make, we are going to be inevitably linked in terms of our capacities and opportunities. And that’s a very good thing.

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A Network the Size of Texas

Texas A&M University and the University of Texas jointly created and support a high-speed asynchronous transfer mode (ATM) network for the state of Texas. The goal of deploying this network was to provide a bandwidth-scalable platform with the ability to support quality-of-service (QoS) and traffic engineering capabilities to ensure that each of the partners of this project would receive their equitable share of the provisioned bandwidth. The previous network consisted of two separate time division multiplexed (TDM)-based networks, which had less capability and significantly higher cost than the new network. This network is unique in that it has become a state-wide, higher education-managed ATM backbone partitioned to support high-speed Internet access, both H.320 and H.323 video, and some limited voice services.

Successfully deploying this unique network required an equally unique partnership. The network operations teams of two separate institutions had to be able to co-manage several switching nodes as if they were one organization. Texas A&M and the University of Texas worked together to create a network that is the ultimate in community outreach; it is the Internet access point for about 70 percent of all public institutions (other than state agencies) within the state of Texas.

Each of the two universities has about 11 sister campuses in its system. These remote campuses each receive Internet access, limited voice services, and links that support videoconference services for both distance education and administrative videoconferencing. This network also provides Internet access and distance education videoconferencing services to approximately 400 other independent school districts, community colleges, universities, cities, counties, and other state agencies.

The state Telecommunications Infrastructure Fund (TIF) Board granted over $2M in funding for this joint project. The TIF Board is a state agency that collects $150M per year from telephone companies to fund enhancements to the state’s telecommunications infrastructure and increase delivery and sharing of information among TIF-funded entities. Texas A&M University and the University of Texas created significant leverage by matching these funds.

The planning process of converting to an ATM-based network involved dealing with multiple university organizations, vendors, and technologies. Organizationally this network required the planning efforts of not only the two universities overall but
also several individual organizations within both institutions. At Texas A&M, the planning involved the data communications group, the video group, and the telecommunications office. At the University of Texas, the planning efforts involved data communications, video conferencing, and the telecommunications offices.

The ultimate goal of this project was to create a more reliable, more cost effective, and more flexible backbone infrastructure that would support Internet access and distance-learning technologies for all of the constituents. This goal is consistent with the Vision 2020 initiative of Texas A&M University that strives to be a consensus top 10 university in the area of telecommunications by the year 2020.

Considering the Challenges

Because there was a significant amount of diverse-vendor–embedded legacy equipment that could not be discarded, the planning process for this network conversion was extremely complex. The initial network architecture required interoperability testing between two vendors of fairly immature architectures. The University of Texas had been using Cisco equipment for their major switching nodes, and Texas A&M University had been using Marconi (formerly FORE). Converting to an ATM-based network required the creation of circuit emulation services that were tunneled through the ATM backbone.

Also, because both institutions had existing ATM networks in place, an address plan had to be established that allowed the two networks to seamlessly mesh. Since there was no numbering plan in place, address space was registered with the IEEE not only to serve both of the university systems but also to address the needs of all state agencies. Services layered on top of the network include variable bit rate (VBR) and circuit emulation services (CES) across inverse multiplexed over ATM (IMA), DS3 (44.7 Mbps), and OC-3 (155 Mbps) connections.

The final design involved five major switching locations in Texas: Dallas, Austin, College Station, Houston, and San Antonio. Of these sites, three resulted in the installation of Marconi switches and two Cisco switches. Two of the five sites are on Texas A&M University campuses and three are on University of Texas campuses.

In the two systems there are more than 200 H.320 videoconference systems that were designed to work in a TDM environment. Therefore, in addition to the ATM layer management issues, the two universities had to create a Layer III QoS strategy that would allow the ultimate migration of the H.320-based video services to H.323-based video services.

The technology implemented in this project is ATM, which has two major advantages: scalability of the network and the ability to support QoS. The switching nodes initially support
OC-3 connectivity between the switches on the trunk side. The switches installed support OC-12, with just the installation of an additional card. Bandwidth rates of up to OC-48 (2.4 Gbps) can currently be utilized with the addition of the switches. Even if these switches were added, the initial group would be integrated into the solution, protecting our investment. The line side (connection to the end users) of the switch support bandwidth rates that include T1 (over CES), multiple T1 (over IMA), DS-3 (45 Mbps), and OC-3 (155 Mbps). This technological flexibility allows the two universities to customize the amount of bandwidth required at each site, whether it is a 47,000-student campus or a single-building school district with 200 students.

Internet applications are rapidly changing. University environments have gone from a predominantly e-mail-based network to one where the Web has become the major application. It appears that real-time applications, such as voice over IP, H.323 video, and streamed multicast video may be major applications in the future. This uncertainty demands that infrastructure currently installed must be able to support QoS or differentiated services in the future. ATM supports guaranteed bandwidth with its committed bit rate (CBR) and VBR services.

This project began with informal discussions between the two universities in 1999. Plan finalization and funding requests took place in 2000. Texas A&M and the University of Texas submitted several individual and collaborative proposals to the TIF Board and garnered institutional support. The first OC-3 link was installed in January of 2001. The final backbone link was installed in July of 2001.

While the project began as a series of informal what-if discussions, it soon evolved into a formal process supported by both university systems. Each school had to analyze the impact of this conversion on the reliability of each of
its existing networks, as well as how it aligned with long-term plans and directions. Two memoranda of understanding between the two universities addressed issues about management of the shared switch resources and the allocation and cost sharing of the common bandwidth.

High-Priority Issues
It is imperative in deploying a network of this scale that quality be a top priority. In this project, the quality measures were threefold.

The first involved the selection of an ATM platform that would provide the highest level of reliability and flexibility available. It needed to be able to grow at multiple T1 increments to keep up with the future demand of the Internet.

The second quality measure involved the selection of multiple carriers for the ATM backbone, such that a single outage would not knock out the entire network. This is critical because the network supports both research and production traffic.

The third measurement involved the monitoring of bandwidth on the links themselves. Because the network is growing, it is imperative to have the ability to predict when the large trunks are going to reach maximum capacity. This is crucial because adding another OC-3 is not a simple or inexpensive proposition. To do this, a Web-based performance-monitoring tool called E-PRO was enabled to plot utilization and do long-term projections based upon linear regression. This was not a simple task because most tools are geared toward private-line circuits, not virtual circuits carried over ATM backbones.

Cost benefit and risk analysis was a critical part of the process. There is a significant cost benefit to concentrating all services on a single ATM backbone. There is also a large risk because all of the "eggs are in one basket." The services carried on the network include not only Internet access but also financial, library, and student information management data for the Texas A&M University System and the University of Texas System. In addition to university-related traffic, the network also carries the Internet services for several hundred other institutions within the state of Texas.

Satisfied Customers
Customer satisfaction is difficult to measure in a project like this because the hope is that the network is completely transparent to the end-user. However, significant feedback from the various institutions connected to the network indicates that it is cost-effective and reliable. Perhaps the best indicator of quality service is new requests for connectivity; we consistently receive requests to broaden the reach of the network.

The Texas A&M University System Telecommunications Council has been a part of the planning process from the beginning. The council is composed of all of the system components within the Texas A&M University System. Feedback received from the members that have been involved in the conversion has been very favorable. The University of Texas System Technical Advisory Committee has reviewed the project and is also supportive of the effort. The majority of the problems that have been encountered to date involve a lack of facilities on the part of the carriers to be able to provide OC-3 links to the various cities.

"While Texas A&M University and the University of Texas are well known rivals when it comes to academics and athletics, we have a long tradition of collaboration when it comes to telecommunications," states Walt Magnussen, associate director of telecommunications at Texas A&M University. "Being the two largest university systems in the state of Texas as well as the Internet service provider for several hundred school districts and colleges has made the joint venture ATM backbone project a necessity if we are going to avoid wasting taxpayers' dollars and sustain the growth that our customers demand. This project not only benefits the state, but it was a real pleasure to work on since it allows us to work with our counterparts at UT."

Material for this article was taken from the application for the 2001 Institutional Excellence Award. Contact Texas A&M's Walt Magnussen at wmagnussen@ppfs4.tamu.edu or University of Texas' George Denbow at gdenbow@mail.utexas.edu for more information.
Networking Explained

2nd Edition

Authors: Michael Gallo and William Hancock

Digital Press, 2002: 672 pages

Reviewed by Walt Magnussen, Texas A&M University

All too often technology books take a dull approach to delivering information, and that makes it difficult to sit down and read the book from cover to cover. Most of these books become reference material that is only referenced with a specific question. This is not the case in Gallo and Hancock's Networking Explained. The book is written in a conversational style that poses several questions about each chapter's subject, and then proceeds to answer each question as if an actual discussion were being carried on between two people. This approach makes the reading both easy and enjoyable.

The book has 18 chapters, five appendices, and a 49-page glossary that is one of the most complete I have seen (short of Newton's Telecom Dictionary). The chapters cover the full range of subjects from basic network principles to Ethernet, from dial-up modem service to ATM, and from "What is twisted pair?" to network security issues. There are two timely chapters, "Network Convergence" and "Wireless Networking", added for this edition, both containing up-to-the-minute information about these two rapidly changing technologies. There are two chapters on older networking technologies, token ring and FDDI, that could have been either shortened or omitted completely without diminishing the value of the book, but I found nothing omitted from the discussion of the gambit of technologies currently available to us.

The target audience for this book is anyone with little networking experience who needs to understand how and why things work as they do in the field of data networking. The authors themselves admit that this is not a "how-to" book. It covers topics at a higher level so that the reader can easily understand how networks work.

Each chapter begins with an historical perspective of a particular technology followed by an explanation of how the technology works and for what it is used. Finally, the conversation ends with a discussion of the authors' vision of the future direction for each specific technology. I agree with the authors' forecast in every case. Attesting to their insight, they offer no forecast in the outcome of which technology will eventually prevail, H.323 or SIP, in the chapter on convergence.

I recommended this book to all of the support staff who work in our offices who do not work directly with the various technologies. For example, our customer service associates working with cellular customers would benefit from the information in the chapter on wireless networks. I also teach a series of continuing education classes in data communications, and this would be an excellent textbook to accompany that course.
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From the Executive Director
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The USA Patriot Act
In the area of security, there was much discussion of the USA Patriot Act and state antiterrorism laws that have been enacted in eight different states so far. Universities are facing the challenges of maintaining freedom of scientific inquiry and public access to information while recognizing the need for network and content security. The library community is very concerned about the removal of thousands of government documents from libraries and government Web sites.

Under the new Patriot Act, the definition of technology which is familiar to telecom managers (trap and trace, pen register) has been extended beyond voice records to include any process or device used to collect non-content parts of electronic communications (e-mails). This includes dialing, routing, addressing, and signaling information, and is being interpreted to mean e-mail headers minus the subject lines. In addition, some requests for information that previously required a court order may now be obtained without court order. A Justice Department representative reported that universities as providers of communications services may immediately disclose information that they believe pertains to immediate danger of death or serious physical injury, and they are immune from liability for doing so.

These and many other aspects of the Patriot Act make it absolutely essential for your department and your institution to have clear, written policies and procedures regarding interaction with law enforcement, and to make sure that personnel are fully informed about those policies.

Campus legal counsel will need to be more involved than ever in developing and reviewing these policies and procedures.

Industry Trends
Finally, a nationally recognized computer and network security consultant covered several industry trends:

- More centralization of security responsibilities, creation of a chief security officer
- Outsourcing some security functions, particularly when you need the expertise immediately and do not have it in-house. It can take 3–5 years to fully train in-house personnel.
- Expectations that security measures will be included in software and hardware products
- Particularly important for universities, there will be increased “third party” liability for Denial of Service (DoS) attacks. As a result, if the university’s network is used to commit a DoS attack, you can be sued by the victim and could be found liable if your system was not sufficiently secure, even if the attack originated off campus.
- Third-party audits of computer and network security, conducted by an outside auditor and reporting directly to senior executives or the Board of Directors, not to the CIO
- Distributed firewalls at the individual machine level that determine what access each machine is given to network resources. This is a newer technology that the consultant believes holds much promise.
- Various organizations are beginning to offer certifications for network security personnel.

I hope these brief highlights of the conference are helpful in raising questions that you may want to address on your campus. Please feel free to contact me if you would like more information or contact information for the conference speakers. As always, I can be reached at 859/278-3338, ext. 25, or jsemer@acuta.org.

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From the Executive Director

Focus on Intellectual Property and Network Security

The Networking 2002 conference held last month in Washington, D.C., focused on two related issues of interest to higher education technology professionals: security and intellectual property. These issues will be increasingly relevant to many ACUTA members as institutions are required to comply with new and changing intellectual property laws and regulations and the need for enhanced computer and network security grows.

There is increased legislative activity in the area of copyright and intellectual property that ACUTA members should be aware of. While none of this new legislation has been signed into law as of this date (late April), it is best to be informed and prepared.

**Digital Millennium Copyright Act**

Much of the new activity stems from a belief by some lawmakers and interest groups that the Digital Millennium Copyright Act (DMCA) of 1998 did not fully address the concerns of interested parties. Congressman Rick Boucher (D-VA) reported that he would be introducing legislation to correct what he perceives as flaws in the DMCA that tipped the balance in favor of content owners as opposed to universities and others that seek “fair use” rights to use copyrighted materials in teaching.

For example, DMCA makes it a crime to circumvent a technological barrier to copying copyrighted material, even if the copy would be for “fair-use” purposes. It is also a crime to “traffic in a circumvention technology.” As a result, a court decision recently prevented a professor from publishing his research into encryption methods. This type of limitation on publishing academic research is a real concern for the academic community.

Boucher is also seeking legislation to expand the protections afforded universities in using copyrighted material for distance learning via television broadcast to include courses that are delivered via the Internet.

Rep. Boucher’s remarks indicated that he believes the key issue to be addressed is that fair-use rights need further legislative protection, and he will be drafting a “Digital Consumer’s Bill of Rights” to address these concerns.

**The TEACH Act**

Another bill currently pending in Congress (5487, the TEACH Act) would explicitly extend the fair-use protections that currently apply to classroom teaching and distance learning. While this Act is designed to protect both synchronous and asynchronous courses delivered via distance-learning methods, it would not permit the showing of a full movie, for example.

Why is this important to ACUTA members? For those members who are responsible for data networks, you may be asked to take a leadership role in developing and administering licensing agreements and usage guidelines. You will almost certainly be encountering increased technological controls designed to prevent copyright violations—either developing compliance systems for users on your campus or coping with controls that are incorporated into materials by manufacturers.

*continued on page 47*
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