The Internet of the future, it is claimed, will energize and transform learning, commerce, scholarship, design, entertainment, and many other activities. Mark Luker, a primary architect of Internet2 for the National Science Foundation (NSF) prior to joining EDUCAUSE as vice president, describes a vision of the world in which every person, every source of information, and vast numbers of other objects of interest are interconnected by a communications system of truly staggering proportions that is easy and affordable to use.
What is the Advanced Internet?

There are many technical ways to describe a qualitative leap in capabilities of an advanced Internet, but these approaches have not proved very useful: technology can advance in leaps that quickly leave the old descriptions behind, and such technical definitions speak only to technicians. It is far better to describe desired and potential services from the point of view of the user.

The chief needs of the user are assumed to be convenient and affordable access to a network that provides simultaneous, high-quality audio and visual communications between all parties of a conversation, in addition to links to the world of instruments and information. Such a network will evolve from today's Internet in a step-by-step fashion. Lack of high quality access outside campus local area networks (LANs) is perhaps the greatest deficiency in today's academic Internet.

Applications

Two academic applications arise in nearly every discussion of an advanced Internet:

The first is collaboration for research. This calls for a complex system of communication and information tools that make it appear that all the collaborators and their instruments, libraries, and technical assistants are in the same place. At one extreme, this could mean connected CAVEs—cave-like automatic virtual environments with video walls, floor and ceiling in which participants work together by literally walking through their data in a three-dimensional virtual world.

Collaborative research is already a success story of today's Internet; however, two key improvements would greatly advance current efforts. First, the Internet needs general improvements to allow ultra-high performance networking of machines that will bring about revolutionary progress. One example is the connection of a grid of remote telescopes that, working together, are larger than any single one could ever be. The other avenue of improvement in remote collaboration is much more problematic: networked access to libraries is crucial to progress, but today access is mostly to library catalogues, not their actual contents. This step demands the introduction and regular operation of digital libraries. It is expected that digital libraries and an advanced Internet will completely change the authoring, publication and distribution of all types of information.

The second application most often cited is distance learning. In today's Internet, this field has moved beyond the talking heads of broadcast television to a more flexible, asynchronous approach in which students interact with lesson material and solve problems at their own pace through the Web. A complete solution would require the support of high-quality communications and collaboration between students and teachers as well, reflecting the basic network requirements of collaborative research. The major hurdle facing the advancement of distance learning today is affordable access. The ideal—access anytime, anywhere, for every learner—multiplies capacity requirements far beyond the performance of today's Internet. Higher education is fortunate, however, that the same basic capabilities and distribution requirements are necessary for electronic commerce and even entertainment.
Access to distance learning is just a first step. Once technology makes it possible, the current lecture-based system may largely be replaced by a very different mode of instruction, with a rich variety of on-line experiences, tutoring, and group studies conducted through the network.

How Can We Achieve an Advanced Internet?

A group of prominent national leaders at an NSF sponsored workshop hosted by EDUCAUSE recently agreed, as have others before them, that an academic/government/industry partnership remains essential for the support of advanced networking for science and engineering, as well as for the science of networking itself. The spiral diagram in Figure 1 illustrates the role of the different players and economics at each stage in the development of a new technology.

Early government funding of the ARPAnet and NSFnet led eventually to today’s largely privatized and commercialized Internet. In 1997, the vBNS (very high speed backbone network service) became the core network supporting a new NSF supercomputing program called the Partnerships for Advanced Computational Infrastructure (PACI), which unites dozens of universities and two major supercomputer centers in joint research projects. The government also has instituted a new program called the Next Generation Internet, or NGI, whose goals are to develop network technology at least 1,000 times better than today, to link over 100 universities with a research network at least 100 times better than today, and to develop a new family of important applications that highlight and depend on advanced networking.

The Higher Education Response

Higher education no longer enjoys the status of dominant customer of the commercial Internet. Research and development projects in advanced networking, however, can still have considerable lever-
age in the design and implementation of the next generation.

In 1998, 130 universities formed UCAID, the University Corporation for Advanced Internet Development, a non-profit corporation focused on an advanced network project called Internet2. Members invest $25,000 per year in dues and a projected $500,000 per year in development of advanced campus networks and connections. Since UCAID universities include most of the recipients of NSF connections awards, the Internet2 project is a natural locus for national coordination of development efforts for advanced networking in higher education. UCAID strategy also includes substantial and essential collaboration with some 30 corporate partners.

At this point, higher education is presented with several unique opportunities. It has reached a critical mass in connections to the vBNS, the world's first major high-performance network for research and development. It has successfully organized UCAID and its advanced network project Internet2, and has built solid relationships with a variety of industrial partners who wish to participate and contribute their skills. It can anticipate possible increases in government support for advanced networking. Perhaps most important is a broad and growing appreciation for the vision of advanced networking.

Conclusion

Many varied issues related to technology, economics and politics must be addressed throughout the quest for advanced networking. Vociferous debate continues at the levels of engineering and marketing over which technologies will prove best in the end. Pricing discussions are complicated by philosophical questions over social values and rights to access. The extent of the government's role in stimulating progress, and just whom the advanced network should be designed for are also subject to debate.

Although the costs and opportunities for advanced networking may seem very uneven at this point, one need only look at today's Internet to see that in the long run, these activities will prove to be a great equalizer. All are empowered once they gain access, however distant; all benefit from the access of others. When the dust settles after the construction of advanced networks, the real challenge will shift to the providers of information, communications, and knowledge services, including higher education. All will have the opportunity—indeed, the imperative—to rethink and transform their services.

Mark Luker served as program director for advanced networking at the National Science Foundation and the federal Next Generation Internet project prior to joining EDUCAUSE as vice president. At EDUCAUSE, he heads a thought-leadership coalition of university CIOs and state network directors whose goal is to advance national networking for research and education through joint projects and federal policy.