

Networking and the Internet

1. Why will the high-speed Internet work for distance learning when two-way video never achieved critical mass?

Glenn Ricart, Co-founder and CTO, CenterBeam: Learning involves not only receiving information but practicing the application of that information in the context of previous knowledge. Critical thinking is stimulated by interactivity (at first two-way and later multi-way) with simulated and/or real-world models, with the instructor, and with other students. A strong sense of presence encourages interactivity. Television is associated with passivity. The Internet is associated with interaction.

J. Gary Augustson, Vice Provost for Information Technology, Penn State University: First, two-way video has still not reached maturity—it is complicated and cumbersome to use—whereas the “Internet technology” has already taken root. Second, the tools available today are much more sophisticated, as are the capabilities they enable, providing not just streamed lectures but truly interactive simulations and modeling. Finally, the world environment has changed. Today’s more technically sophisticated end-user population has a real need that must be met. This is a much friendlier environment for success.

Richard Guida, Chair, Federal Public Key Infrastructure Steering Committee: The Internet provides much more than two-way video/voice communication. It allows authenticated and confidential submission of homework assignments and even tests, the ability to replay lessons or information on a 24-by-7 basis, and the ability to collaborate remotely with other students on projects.

Michael M. Roberts, Interim President and CEO, Internet Corporation for Assigned Names and Numbers: Two-way video was far too expensive and inflexible—by a factor of 10 to 100 or more. And it did not offer the interactivity of computer mediation and administration. In other words, it just inserted a very expensive communications link into a traditional classroom setting.

George Sadowsky, Director, Academic Computing Facility, New York University: The real value of high-speed Internet connectivity for distance learning has yet to be measured in any overall sense, but this is more of a pedagogical issue:

identifying how to create effective interactive learning environments in this new space and under what conditions they work or fail. What the Internet provides is the promise of an inexpensive one-to-one—connectivity between teacher and student and between fellow students—that analog video could never economically deliver.

Douglas E. Van Houweling, President & CEO, University Corporation for Advanced Internet Development (UCAID): Two-way video alone simply attempts to substitute an inferior communication capability for in-person communication. Advanced Internet provides a more flexible video interchange environment and adds the ability to simultaneously interact with remote instruments, visualize computer models, and access global information resources. When video is run through a standard network into a computer, expense is reduced, setup is simplified, and access is ubiquitous. Further, you can couple the video with the other modalities that computers enable.

2. Will campuses continue to operate their own networks in the future?

Ricart: Yes. It’s all about location, location, location. The newer networking technologies annihilate space but do so by being very geographically specific. Local low-power radio makes small, Internet components both feasible to connect and mobile. Fiber will interconnect radio cells. Until campuses outsource their buildings, they’ll operate their own networks.

Augustson: Large, Research 1 universities—like Penn State—most likely will. Outsourcing such functions adds very little value (and incurs very high costs). Even more important, it is hard to stay on the leading edge if you are relying on a service provider driven by the profit motive. At the same time, I would not be surprised if some new partnerships develop that would make it attractive to consider new models of providing such service.

Guida: Yes, simply because that allows each institution to retain a degree of autonomy, to continue to operate even if the centralized infrastructure is disabled.

Roberts: This is not an important question. If it becomes desirable to outsource net operation, then campuses will undoubtedly do that.

Sadowsky: Campus networks have historically been spaces where experimentation was encouraged, resulting in rapid

innovation. Campuses will continue to benefit from managing their own networks as long as academic innovation depends on the possibility of reshaping that infrastructure to serve new needs of the community. The services that are capable of being delivered over the Net are still in such a state of flux that operation and control of the network will be necessary for the foreseeable future.

Van Houweling: I believe most research universities will, at least for the next five years. As data networks stabilize, their management will likely be coupled with voice and video and operated in a consistent fashion. Outsourcing such a strategic infrastructure may not save money, and it usually limits flexibility and priority setting.

3. In what sectors can we most expect network innovation to emerge?

Ricart: Small, specific-purpose Internet components will emerge. The larger Internet forms a support infrastructure for them, simplifying their design and reducing their cost. In addition to the personal-accessory components mentioned in my article, look for Internet components that implement home automation, building access and security, navigation (through malls, through large conference centers, around town), continuous personal medical monitoring, and virtual private clubs. In addition, the components will allow you to escape your always-connected world occasionally for moments of solitude and reflection.

Augustson: My experience has shown that advances are most accelerated when various sectors collaborate. I am still a strong believer in the public/private partnership that was so effective in launching the initial Internet—and that has played such a key role in advancing the Internet2 initiative. In the future, the “killer apps” that end users demand will be key to innovative change. We must find innovative networking solutions that enable the translation of their innovative thoughts into solutions.

Guida: Toward stronger authentication and security. Expect to see the emergence of technologies like smartcards, which allow mobile users to authenticate themselves strongly from multiple workstations—thus increasing flexibility and the spectrum of uses to which the network can be put.

Roberts: Specific innovations are hard to predict. But obviously, present networks still suffer from lack of quality of

service and reasonable feedback to the user about what is going on and from far too many complex user procedures to obtain service. At a more macro level, the development and integration of broadband network services, including middleware components, into a new generation of fully interactive, multimedia applications is in its infancy.

Sadowsky: That's one of the wonderful things about this technology: the law of unintended consequences is alive and active. The Internet was originally built to share distributed computational resources but was soon taken over for communication. Now we're using it largely to provide access to distributed content, generally via the Web. I'd rather ask the question, “How can we ensure that we maximize the possibility of continuing innovation in network infrastructure and network services?”

Van Houweling: Within two or three years, broadband wireless communication will expand and diversify its offerings, enhancing both coverage and performance. Agent technologies have only begun to make their impact and will enable people and organizations a persistent, active presence on the Net. As middleware is deployed, a large number of pending applications will become viable and widely used. Lastly, “flocks” of sensors on the Net will create a new class of interesting services in areas from seismology to weather forecasts.

4. What is the long-term future of network organization and management?

Ricart: Networks will self-organize and self-manage. Displays will show where additional network resources need to be placed to handle current and anticipated demand. Network components will have their own bartering system and/or transfer of payments to handle tradeoffs between communication paths and storage and their latency. Applications and users of the network will add external value (typically dollars) to the network, and the network will have an internal economy to redistribute those dollars to the bottleneck areas.

Augustson: You can talk about reorganizing (or outsourcing) a department, hiring (or firing!) a CIO, centralizing (or distributing) networking functions, but in the end it comes down to the skills of the team's key players. Regardless of what the new breed of leaders may think, it doesn't all “just happen.” For organizations to be successful in the future,

the technology leaders—whatever you may call them or however you may formally structure them—must get “a seat at the table” where the strategic decisions are made.

Guida: Stronger authentication and security. If this sounds like a recurring theme, it is. Networks that lack these elements will be compromised, users will become distrustful, and the system will lose its ability to service their needs.

Roberts: Network managers will respond to the needs of their users as they have in the past, but at a higher level of involvement and support, since the network, instead of being useful, has become indispensable. As institutional missions adapt to Internet-centric forms of learning and scholarship, successful network managers and their CIO bosses will become much more involved in strategic planning and execution of academic programs.

Sadowsky: In the long run, the network will become more and more invisible except when it breaks, much like the mature infrastructure networks of today such as electric power and plumbing. But network connectivity may well separate into different flavors, with different characteristics. It's too early to tell, and I'd be very wary of premature specification in the face of how ignorant we are about the limits and potential of this technology.

Van Houweling: On campuses, network organization is being folded into an overall communications organization, usually as part of a larger central IT unit. Between campuses, we can expect several high-performance backbones. Multiple service providers can create competitive pricing but will increase the difficulty of end-to-end management and diagnosis. Regional aggregation points, such as gigapops, are likely to persist to create local economies of scale, buffer campuses from the complexity of interacting with multiple providers, and offer continuing technology-transfer mechanisms.

5. What key issues remain to be solved for networking in higher education?

Ricart: (a) Technological: see my article. (b) Social: we need methods of didactic instruction and encouragement of critical thinking that leverage rather than tolerate networks. (c) Legal: higher education depends on free access to accumulated knowledge via libraries and their financial contributions; how do we proceed when libraries are disintermedi-

ated? (d) Governance: how can network evolution remain cohesive and interoperable with the large number of disparate players now in the game? The existing standards mechanisms are fractured and strained.

Augustson: Two key issues continue to be scaling and affordability. At Penn State today, we have over 100,000 users of our networks; as we move to more “distant support” areas (embracing distance education, alumni affairs, development, etc.), this number will climb to several million users. I worry a lot about how we can effectively—and affordably—support this worldwide base of users within the timeframe they will demand.

Guida: Authentication for remote users, support for mobile users, security for network servers to guard against intrusive attacks and denial-of-service attacks.

Roberts: Though all levels of university management now acknowledge the importance of the Internet, institutions have not yet internalized the investment requirements for the high-performance Internet of the next decade or two. Conventional budget processes, dominated by competitive strife over proportional shares of budget support, are far too slow to accommodate the onrush of the Internet's impact on teaching and research. Successful academic leadership will treat the Internet as a revolution demanding revolutionary internal changes.

Sadowsky: How can we transfer our vision of the substantial long-term academic and other benefits of network technology to the administrators who are being asked to pay for getting us there? How can we generate the middleware and other tools that will allow for efficient faculty adoption and use of network services? I think these questions will recur at different stages of network growth, and we will be answering them again and again.

Van Houweling: The greatest challenges lie in learning to use the network—technically, personally, and socially. Technically, tuning an application to extract the required performance is still an art rather than a science. Personally, we need to become comfortable with the applications that depend on high-performance networking. Socially, we need to learn how to build the collaborative organizational environments required to parallel the emergent collaborative technology we are depending on to enhance our primary teaching and research missions.