Internet2—Creating Tomorrow's Internet

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A broad consortium of organizations works internationally to develop the Internet of tomorrow, allowing research and collaborative relationships that can foster greater innovation, stronger collaboration, and better education.

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Internet2 is a not-for-profit U.S.-based consortium led by 208 U.S. research universities working in partnership with 70 corporations; nearly 50 government agencies, laboratories, and associations; and more than 45 international partners to develop, deploy, and use advanced network technologies to accelerate the creation of tomorrow's Internet. To enable researchers, scientists, and students to participate in this cutting-edge technology research, Internet2 has deployed a high-performance network across the United States called Abilene. The network connects 240 of Internet2's member institutions and 34 state education networks, and interconnects with similar leading-edge research networks in other countries. Abilene is engineered with the most cutting-edge network capabilities to give users speeds thousands of times faster than typical home broadband connections.

Photo montage: An international consortium is working to develop the next generation of the Internet. Their efforts already have made it possible to conduct educational demonstrations in real time by streaming high-quality digital video; to produce and share three-dimensional, digital images of precious artifacts; and to connect expensive scientific equipment, such as electron microscopes, for multiple users at different locations. (Clockwise from top left: Courtesy *http://www.internet2.edu* (2); Bradley University; Stanford University)

Internet2 and its partners are working to fundamentally change the way we live, learn, work, and play. Our community believes the network of the future will support a whole new set of applications—immersive collaboration environments, real-time computation-intensive simulations, high-definition television-quality video on demand, and others that probably can't even be imagined today. Already, students around the world can experience live real-time demonstrations of underwater exploration with famed oceanographer Dr. Bob Ballard, using DVD-quality videoconferencing technology, or dissect an anatomy specimen thousands of miles away with remote surgical instruments. Meteorologists at the National Oceanic and Atmospheric Administration use Abilene to make faster and more accurate severe weather predictions; astronomers control telescopes located in the remote regions of Hawaii and Chile without leaving their home institutions.

As these examples illustrate, research and education have become increasingly collaborative and dependent on simultaneous access to facilities, data, and people located around the world. It is no longer sufficient for U.S. researchers to have access to a high-performance, dedicated U.S.-centric network infrastructure. The same kind of dedicated, high-performance network infrastructure is needed internationally. To support and promote this worldwide cooperation, Internet2 created an international relations program to partner with similar organizations around the world to interconnect Internet2's U.S. network with its global counterparts. Together with the international research community, Internet2 believes that global collaboration will foster innovation in areas ranging from science and medicine to the arts, and will enhance economic growth in developing nations.

Today, many countries have established dedicated, high-performance National Research and Education Networks (NRENs) to support the needs of their own research and education communities. NRENs can be found in almost all the countries of western, central, and eastern Europe; most of Asia-Pacific; an increasing number of countries in southeastern and southern Asia; and in several countries in northern Africa and Latin America.

The value of each NREN is multiplied as individual networks connect to form a global research and education network infrastructure. Today, a typical NREN has to connect into only one or two other NRENs to reach the entire international research community. This high-performance network infrastructure is used to support, for example, thousands of researchers from dozens of countries involved in the Large Hadron Collider experiments at CERN (European Organization for Nuclear Research) in Geneva, Switzerland. The commercial Internet is simply not capable of transferring the massive data sets required for this type of experimentation between participating research institutes.

NRENs also support domestic and international collaboration in the arts and humanities and health sciences. For example, Stanford University's HAVNet project (Haptic Audio Visual Network for Education and Training) illustrates how medical students are gaining hands-on surgical training from remote experts thanks to advanced connectivity. Whether dissecting virtual hands, performing surgical procedures on simulators, or witnessing a surgery remotely, students are able to participate in the learning process from multiple locations simultaneously. Likewise, specialists from around the world are able to connect virtually

Photo montage: The Internet2 consortium includes 208 U.S. research universities; 70 corporations; nearly 50 government agencies, laboratories, and associations; and more than 45 international partners. (Courtesy *http://www.internet2.edu)*

to work with students on unique procedures—even physically guiding a student's hands from a remote location as they attempt a surgical simulation. This type of intensive instruction produces more informed, more prepared medical students who are better equipped to head into the operating room.

A recent U.S. National Science Foundation-sponsored workshop on the subject of a digital library of the Middle East illustrated that the humanities can also benefit from international NREN connectivity. Precious artifacts of the Middle East are now being digitized, many using magnetic resonance imaging (MRI) technology, to produce three-dimensional virtual objects. Through high-performance research and education networks, researchers around the world can examine and manipulate these rare objects from afar, with access granted to many more scholars than previously would have been allowed to physically handle the artifacts.

Pooling resources to interconnect universities in a country and then to other university networks is as critical for the higher education and research communities of a developing country as for a developed one. Developing countries are increasingly looking to NRENs as an important way to expand their own research and higher-education enterprises. For example, scanning electron microscopes—instruments that use atomic particles called electrons rather than light to form an image—are typically too expensive for every university to afford. By connecting these microscopes to an advanced network, it is possible for users to remotely control the microscope to examine their specimen via a high-quality digital image.

In developed and developing countries, obtaining better access to the underlying telecommunications infrastructure has proven crucial to the success of NREN efforts. In many countries, the NREN has played a key role in fostering the development of new communications infrastructures. For example, in Poland, the NREN was successful in partnering with the railroad company to lay new fiber-optic cable across the country. Now, PIONIER, the university and research network of Poland, has access to dark fiber (fiber-optic cable that is in place but not yet in use)—the raw element of building a high-performance network—and is no longer beholden to a traditional telecommunications provider's services. Poland, the Czech Republic, Slovakia, and other countries of Eastern Europe have all followed this model, at times leapfrogging the NRENs of Western European countries in their ability to access high-speed fiber infrastructure.

Internet2 and its international partners will continue building the dedicated, high-performance network infrastructure in support of the research, teaching, and learning needs of the global community. Based on Internet2's experience so far, the innovation and experiences of this community and its interest in building advanced network infrastructure will lead to a smarter, faster, more reliable, and more secure Internet. In doing so, we will enable new ways to conduct science, to engage in business, to educate anytime and anywhere, and to bring communities and families together in rich new ways. The research and education community is optimistic that such an Internet will be realized through the combined efforts of organizations like Internet2 all over the world. ■

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government.