Cultivating Global Cyberinfrastructure for Sharing Digital Resources

The World Wide Web and associated Internet resources have emerged as the largest distributed data repository on earth. Human knowledge from all over the world resides on the Internet in various digital forms: data sets, web pages, journal articles, digitized books and newspaper articles, blog posts, scanned drawings and paintings, photographs, videos, podcasts, speech transcripts, and numerous other media. How is this information aggregated, indexed, searched, and disseminated? How does this digital content get from a web server in Malawi or Ecuador to an end user at a college or university in the United States, or vice versa?

Research and scholarship in the 21st century is enabled by cyberinfrastructure—advanced hardware and software connected via high-speed networks. Researchers rely on these tools and networks to access the vast repository of digital content on the web and to share their discoveries with the scholarly community. In North America, Europe, and other industrially advanced regions, students and faculty enjoy relatively ubiquitous and pervasive access to cyberinfrastructure—and therefore to digital content. By contrast, although the requirements of students and faculty in developing areas around the world are the same, the lack of cyberinfrastructure hampers their full participation in the global research enterprise.

In Africa, for example, the lack of affordable Internet connectivity and cyberinfrastructure resources results in the important work of too many researchers being nearly invisible to the international community, as highlighted in the final report of the Workshop for Enhancing Collaborative Research on the Environment in Sub-Saharan Africa, sponsored by the National Science Foundation (NSF).[1] The SSA workshop report recommended that in addition to training for scientists, enhanced training programs for technical and support staff are crucial for the success and advancement of science and engineering. The lack of ready access to networking and cyberinfrastructure not only limits the ability of researchers to reach the international community but also negatively affects the ability of students and researchers to access digital materials available online.

Although many countries are making significant progress in building cyberinfrastructure, that progress is limited by challenges in two specific areas: (1) network infrastructure and human capacity development; and (2) affordable access to software and digital content.

Network Infrastructure and Human Capacity Development

The Network Startup Resource Center (NSRC), based at the University of Oregon, was established in 1992 to provide technical assistance to organizations setting up computer networks in developing areas for collaboration with U.S. scientists. The NSRC is partially funded by the NSF and currently works with the International Research Network Connections (IRNC) community. The IRNC initiative, a strategic program for the NSF, is the cornerstone of future international science and education activities and is the foundation for global cyberinfrastructure as highlighted in the "NSF International Research Network Connections Program Final Report."[2] The NSRC receives additional contributions from more than three dozen other public and private organizations (http://www.nsrc.org/sponsors/) in support of its work to cultivate and help develop cyberinfrastructure with research and education (R&E) networks in less-connected parts of the world.

Numerous organizations in Africa, South Asia, and other regions have requested assistance in creating and expanding R&E networks and national cyberinfrastructure. By designing and building well-structured college/university networks—with all of the campus segments, libraries, and academic departments included—researchers in developing countries can be connected from the desktop to the grid for collaboration with the international R&E community. Having access to well-structured networks allows the academic community to take advantage of the bandwidth of new international submarine cable systems that provide substantial cost savings over satellite network delivery. Professor Meoli Kashorda, Director of the Kenyan Education Network Trust (KENET), noted: "The local network is growing and we are now busy encouraging ICT directors and vice chancellors to think of new, innovative ways to use the network and the high-speed Internet access that is becoming available. Campus networks are now an important area of focus even as we expand the national network."[3]

In response to these requests, the NSRC strategically facilitates large-scale equipment (infrastructure) and book (knowledge) donations from industry, equipment manufacturers, and book publishers and couples those efforts with customized technical training programs. The explicit goal is to help advance both physical and human cyberinfrastructure resources locally. From 1992 through 2009, the NSRC distributed networking equipment worth about $35 million and technical reference books (donated by O'Reilly Media, Pearson Education, and other publishers) worth about $6 million. The infusion of routing, switching, and wireless equipment has leapfrogged the development of many campus networks in Africa, Asia, the Pacific Islands, and Latin America and has catalyzed the physical developments of several national R&E networks. The donated books are placed in locations where they can be freely shared: computer science departments, campus libraries, and centrally based networking facilities.

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Genuine cultivation, though, requires more than equipment and books. Network engineers and technologists also seek training, education, and relationships in the network operations community. The NSRC's lab-based technical training workshops (http://www.nsrc.org/workshops/) with network operator groups (NOGs) in numerous world regions provide an effective way to spread knowledge and best practices. The technically intensive, hands-on courses are offered in various locations around the world and on the University of Oregon campus. During the summer of 2009, the NSRC hosted a Network Design and Operations Workshop in Eugene, Oregon, that included professionals from Ghana, Togo, Malawi, Kenya, Bangladesh, Nepal, and China, as well as University of Oregon computer science students.[4]

An outgrowth of NSRC's work with the African Network Operators Group (AfNOG), the Association of African Universities (AAU), and the UbuntuNet Alliance over the past decade has been a number of requests from college/university network engineers (and even some ministry personnel) to help them improve the campus network designs for their bandwidth-constrained communities. In March 2010, KENET and NSRC teamed up in Nairobi to conduct a training program with network operators from more than thirty institutions in Kenya, combined with a donation of 5,000 pounds of routers, switches, and wireless equipment to deploy in Kenyan campus networks. Plans for similar technical programs are under way with partner organizations in Ghana, Nigeria, Tanzania, Namibia, Zambia, Botswana, and Mozambique, and an additional cyberinfrastructure workshop is planned with engineers from the eight NRENs (National Research and Education Networks) of South Asia.

Affordable Access to Software and Digital Content

In addition to technical training, the NSRC courses include opportunities for dialogue about educational technology, library systems, digital repositories, and open-source and open-content initiatives. Discussions during the NSRC Network Design and Operations Workshop in the summer of 2009 revealed that the participants and their institutions are eager and early adopters of open-source and open-content resources. In Malawi, for example, a consortium of universities has implemented the Koha open-source Integrated Library System (http://www.koha.org/). The network administrators offered inspiring stories of library-IT collaborations within their own institutions and in regional consortia. Kondwani Wella, College Librarian for the University of Malawi's Kamuzu College of Nursing, explained: "We have championed Koha in Malawi through the Malawi Library and Information Consortium's Technology Research Group. We have implemented integrated library systems in ten nursing colleges and introduced the software to Mzuzu University."[5]

Collection development is a worldwide challenge, with high subscription costs forming a particularly difficult barrier for students and researchers in developing areas. The higher education community needs to make content from campuses accessible by publishing in open-access journals and repositories[6] and by supporting international digital publication and dissemination initiatives such as SciELO (http://www.scielo.org/php/index.php?lang=en) and INASP (http://www.inasp.info/). The R&E community should also continue to drive down software licensing costs by contributing to open-source software tools that have features competitive with those of commercial offerings.

Finally, researchers in developing areas also contribute innovative digital content, which needs to be made more widely available. Wella noted: "Malawi is a shining example in terms of HIV and AIDS interventions. These could be shared with the international learning and research community. There is research in agriculture (maize), health (nutrition and AIDS), chemistry (cassava starch), and other examples."[7]

To flourish, research enterprises need enabling network infrastructure, well-trained local support, ready access to new technologies, and the ability to both generate and disseminate digital content. The improved communications resulting from these efforts enhance collaboration between researchers and educators on both ends of the connectivity spectrum. Promoting an advanced knowledge infrastructure in an IT-enabled world, with a focus on sharing information resources globally via the Internet, fosters new mechanisms for opening up innovations and research to the entire academic community. ■

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3. Meoli Kashorda, personal e-mail communication with Steven Huter, June 18, 2009.
4. NSRC, "Summer School of Network Design and Operations," July 2009, ⟨http://nsrc.org/workshops/2009/summer/⟩. See also the workshop videos: ⟨http://www.youtube.com/watch?v=6x9psQp_4-A&feature=channel⟩ and ⟨http://www.youtube.com/watch?v=7T_mA51wedQ⟩.
5. Kondwani Wella, e-mail interview, February 16, 2010.
6. For a list of open-access journals, see the Directory of Open Access Journals (http://www.doaj.org/).
7. Wella, e-mail interview.

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