EDUCAUSE Learning Initiative

advancing learning through IT innovation

CyberBridges

Carie Windham

Edited by Diana Oblinger

ELI Paper 8: 2007

September 2007

Abstract

CyberBridges trains graduate students how to use cyberinfrastructure (CI)—a combination of computing systems, applications, and virtual organizations. Supported by NSF, CyberBridges hinges on the hypothesis that technical training of graduate students will not only lead to more rapid scientific discovery but will also trigger greater CI adoption in academic departments. Students are trained in networking and grid computing and then integrate what they have learned into their research to develop innovative tools or approaches. Due to the success of the initial program, CyberBridges has gone "global," involving students in China, Hong Kong, and Brazil.

In 2002, Florida International University (FIU) launched the Center for Internet Augmented Research and Assessment (CIARA) with the goal of helping the university's research faculty take advantage of computational advances. Already immersed in teaching assignments and tenure demands, many faculty could not find time to learn new technologies, particularly complex tools and applications whose jargon obscured the research potential. The staff believed adoption of advanced technology by disciplinary researchers might lead to a higher rate of scientific discovery.

Four years later, CIARA launched CyberBridges, an NSF-funded pilot project that brings advanced graduate students out of their research laboratories and into hands-on cyberinfrastructure (CI) environments. The project answers a call from the NSF to train more scientists and scholars in the complex computing systems, applications, and virtual organizations known as "cyberinfrastructure." While the term is hard to define, CI is about leveraging high-performance and grid computing, advanced networks, and data sets to enable people to solve complex problems.[1] More than that, CyberBridges recognizes CIARA's founding goal to break down the walls between research scientists and IT professionals. If CyberBridges could encourage students to cross into the supercomputing world, CIARA researchers hypothesized, their advisors and peers might follow.

What Is It?

Though the nomenclature conjures images of an intellectual bridge linking graduate students with information technology, CyberBridges is just as much about the ripple effect in the water underneath. CyberBridges hinges on the hypothesis that technical training of graduate students might not only lead to increased scientific discovery and collaboration, but it might also trigger greater CI adoption in their departments, by their advisors, and by other faculty. In exchange for funding and technical training, the CyberBridges Fellows integrate computer clusters into their research—research in fields that might not traditionally employ CI.

"We wanted to demonstrate that really good domain science, information technology, and engineering are not three separate silos," said Heidi Alvarez, director of the CyberBridges pilot. "This is about creating the next generation of researchers and scientists."

"Because of CyberBridges, now there's a buzz among the faculty," explained Alvarez. "If we get one faculty advisor involved, they're talking to their colleagues. It has the effect of bringing in all the departments that [CIARA] is trying to reach."

How Does It Work?

In late 2005, a team of CyberBridges advisors began posting flyers in the halls and library at FIU, advertising four fellowships for students interested in cyberinfrastructure. Recipients would receive training in IP networking, XML, and grid and cluster computing, as well as a $6,000 research stipend and full tuition for two semesters. Alvarez wasn't just looking for computer science researchers or students well-versed in computer networking. Applicants needed some programming experience, preferably C or C++, Fortran, or Java, and a clear research agenda that could benefit from grid computing.

Selection of Fellows

Twenty students applied for the fellowships, and an eight-member interdisciplinary faculty panel reviewed the applications based on a detailed research proposal and CV. The first four CyberBridges Fellows selected hailed from biochemistry, physics, biomedical engineering, and computer science. For the pilot, these fellowships were funded through a grant from the

NSF CI-TEAM program, which funds projects that promote, leverage, or use CI for integrated research or teaching and learning activities. In an external assessment of the program, committee members said careful selection was imperative to the project's success. The committee concluded that CyberBridges benefited from selecting students who were already well-integrated into the research and academic community at FIU.

Classroom Curriculum

After selection, fellows enrolled in a three-credit-hour course called Special Topics in High-Performance Computing and Network Computing. Selection as a fellow was a prerequisite for the course, which was taught by FIU faculty. The first half of the semester, taught by Eric Johnson, focused on the physical components of networking. Students developed computer networks, focusing on troubleshooting, design, and implementation. In the second half of the semester, taught by Chi Zang, students learned about grid computing, high-performance networking, and how to design, build, and maintain their own computer clusters.

Independent Research

Students moved to their own laboratories during the second semester, integrating CI into their research to develop innovative tools or approaches. For example, fellows might leverage their computer cluster to generate more power for simulations or develop new databases for discovery. Although termed "independent study," the work was supervised by faculty mentors and CyberBridges staff to ensure its technical and scientific integrity. During the pilot phase, fellows applied CI architecture to disciplines including biomedical engineering and physics.

- Tom Milledge teamed with CyberBridges staff to create a method for rapidly searching protein databases to find protein structures that share common functions. Because patterns occur naturally, pattern discovery has emerged as a tool for scientists to pinpoint commonalities in specific sequences. Milledge's research focused on the computational work required to search and identify common protein structures through 3D visualization.
- Ronald Gutierrez used 3D modeling to study the effect of hydrodynamic forces and nutrient mass transfer on the surface of scaffolds in tissue engineering. Scaffolds are artificial structures onto which the cells are implanted for the tissue to grow. Gutierrez's research focuses on forces that might affect cell growth and tissue formation.
- Alejandro de la Puente used lattice field calculation to study quantum chromodynamics, which describes the interactions that bind quarks to form protons, neutrons, and other particles. His approach used grid computing to do the calculations, allowing researchers to observe the physical components of the interaction and giving him an opportunity to develop his own algorithms for similar calculations.
- Cassian D'Cunha leveraged CI computing power to run simulations of enzymes, particularly chloroperoxidase. Computer simulations are a common tool in the research lab or the pharmaceutical industry, but they require extensive computer time and memory requirements. The ability to model such micromolecules offers an opportunity to study their mechanics and speeds drug discovery.

Professional Development

At the conclusion of the fellowship, student success was evaluated against academic metrics similar to those used for tenure review. Students were required to collaborate with their faculty mentors on a research paper detailing their experimentation with CI and the research results, and those papers were published and presented at an international conference. The long-term impact will be measured by publications and professional opportunities, such as internships or fellowships.

Why Does It Work?

When Cassian D'Cunha applied to be a CyberBridges Fellow, he saw it as an opportunity to learn more about the computing clusters that were already fueling his graduate research. D'Cunha, a graduate student in chemistry and biochemistry, had been using a departmental computer cluster to run macromolecular simulations of the enzyme chloroperoxidase, much like the simulations frequently used by pharmaceutical companies to research new drugs.

He quickly discovered that CyberBridges wasn't just about learning the complexities of supercomputing, it was about applying them. Students actually build, maintain, and troubleshoot their own computer clusters in class. Students without previous access to a cluster launched their cluster in the second semester. "It was very interactive and hands-on," D'Cunha says. "We built everything from scratch."

D'Cunha took that knowledge back to his research lab, where he reconfigured the existing cluster to better handle the increased data that his research requires. "Our research group requires significant computer resources to achieve our overall goals," said D'Cunha. "I can now use the knowledge I gathered from the CyberBridges project and apply it so that our research group benefits from the efficient use of our computer resources."[2]

For D'Cunha and other fellows, the CyberBridges pilot worked because it provided authentic instruction in cluster design. Students aren't merely thrown into a classroom to learn about computing—they are preselected because their research interests correspond with the benefits of CI. They walk through the door with a vested interest in the material and the project's success. The project also benefits from its small scale and multidisciplinary nature.

Multidisciplinary Approach

The fellows represented disciplines from across the academy, allowing CI to infiltrate departments that might otherwise overlook its potential benefits. Moreover, the students attended lab sessions together and learned how to build the clusters as a unit, giving them an opportunity to learn from each other's research. They learned how to interact with scholars from diverse disciplines, fueling a spirit of cooperation that researchers hope will extend to their future research endeavors.

Hands-On Classroom

Fellows not only learned cluster design but also were active constructors. The hands-on approach broke down the initial trepidation and allowed for smoother integration into their own lab environments.

Individual Research Interests

Graduate students are required to submit detailed research proposals at the time of application. The panel selects students based partially on the applicability of CI to their research. This ensures that students have a vested interest in CI application. Because students are allowed to use their clusters for their own research, time concerns are minimized, given that the fellowship is meant to accelerate, not lengthen, time to dissertation.

Small Scale

The pilot phase awarded four fellowships at the same institution. The scale allowed for easier management and more intimate relationships between the students and the CI professionals. Working within the institution eliminated most scheduling problems.

Institutional Support

Within FIU, the project benefited from ample support from computer science faculty and individual faculty mentors, who agreed to work closely with the fellows. FIU faculty members, nominated by their departmental chairs, also agreed to sit on an advisory committee that coordinated recruitment, selection, and assessment. The institution also bore all infrastructure costs.

Scientific Expertise

Individual research projects benefited from the contributions of mentors from related fields of study, maintaining the integrity of the science, notwithstanding the use of CI. For their coursework, students learned from senior personnel at FIU: Chi Zhang, an assistant professor with research experience in high-performance computing, and Eric Johnson, an instructor in beginning and advanced networking.

What Is the Value?

As the pilot phase of CyberBridges drew to a close in 2006, the fellows, with their faculty mentors, set up presentations detailing their research at the International Conference for High-Performance Computing, Networking, Storage, and Analysis. As the conference started, Alvarez remembers coaching some of the fellows, who seemed more comfortable in the lab than delivering presentations for their peers. “Stand up straight. Speak louder. Don’t fidget,” she would say. After a few presentations, however, she hardly said anything at all. Delivering polished, published researchers is just one facet of the program, whose value extends beyond the fellowships.

For the Fellows

Fellows learned the technical skills required to leverage CI for their own research. In an evaluation of the program, led by Hugh Gladwin of FIU’s Institute for Public Opinion Research, the advisory committee found that introducing CI led to more rapid and computationally advanced research. Moreover, fellows strengthened their resumes by stepping outside of their academic departments to learn cutting-edge computational skills. After the conclusion of the pilot, fellows moved on to competitive internships and graduate programs.

“Being a CyberBridges Fellow strengthened my credentials for this position,” said Tom Milledge, who received a competitive, six-month internship to optimize software on IBM’s Blue Gene supercomputer system. “The practical skills I have gained through the program include the ability to analyze communication patterns and performance characteristics in a parallel processing environment.” Ronald Gutierrez leveraged the fellowship into an internship at Abbott/Guidant Corporation. “As a CyberBridges Fellow, I was more competitive for the internship because I have proven my ability to apply high-performance computing to my biomedical research,” he said.[3]

The program's interdisciplinary approach also encouraged collaboration, teaching students how to interact with their peers across the university and demonstrating the benefits gained by linking their own research with information technology.

For the Institution

It's not merely the fellows' research that benefits. By working intimately with the students, FIU faculty have the opportunity to learn firsthand about the benefits of CI. Milledge's work on protein pattern discovery had been done at FIU—on a small scale—for many years under the guidance of his advisor, Giri Narsimhan. With the CI link established by Milledge's research, Narsimhan predicted the research would expand and accelerate.

CyberBridges presents a model for integrating new information technologies across disciplines. Because fellows were selected from the hard sciences, rather than computing backgrounds, faculty and students who might not otherwise have been exposed to similar computational resources became converts. The institution benefited from a wide dissemination of new technologies.

The CyberBridges project also encouraged a spirit of interdisciplinary teamwork by bringing fellows and faculty together in the laboratory. The university benefited from the example and foundation laid by cooperative collaboration.

For Teaching and Learning

By challenging students to apply CI to complex problems within their disciplines, CyberBridges demonstrates that grid computing can be applied across the academy. The program shows that CI can lead to a faster rate of scientific discovery and the ability to answer complex, computer-intensive problems. The focus on independent student research creates an opportunity for innovation and development.

These impacts complement the report of the NSF's Blue Ribbon Advisory Panel on Cyberinfrastructure, which recognized the potential of CI environments for solving global issues. "Such environments...are increasingly required to address national and global priorities, such as understanding global climate change, protecting our natural environment, applying genomics-proteomics to human health, maintaining national security, mastering the world of nanotechnology, and predicting and protecting against natural and human disasters, as well as to address some of our most fundamental intellectual questions such as the formation of the universe and the fundamental character of matter."[4] The research of CyberBridges fellows may add to this discourse or lay the foundation for future discovery.

The panel also encouraged the creation of "more broadly trained personnel with blended expertise in disciplinary science or engineering, mathematical and computational modeling, numerical methods, visualization, and the sociotechnical understanding about working in new grid or collaboratory organizations."[5] The CyberBridges model is both an opportunity for innovation and a model for education.

What Is Required?

Overhead costs are kept low by relying on the university and individual departments for infrastructure costs. FIU provided classroom and laboratory space, as well as faculty for the program. The research stipend for each student is the primary cost. For the initial year, the fellowships were funded through an NSF CI-TEAM pilot proposal. If outside funding is not available for future implementations, directors hope that departmental faculty will help secure grant or private funding to support the fellowships.

Aside from financial requirements, the projects hinges on the support of individual faculty, who volunteer to work with the fellows on their research projects. Their cooperation, and the cooperation of departmental labs and facilities, is crucial to the project's success.

Where Is It Going?

During fall 2006, CyberBridges went global. Drawing on the success of the pilot project and employing a similar template, CIARA signed a memorandum of understanding with the Computer Network Information Center of the Chinese Academy of Sciences, the City University of Hong Kong, and the University of São Paulo's School of the Future in Brazil and opened the application process for the first class of Global CyberBridges fellows.

Unlike CyberBridges, which allowed each individual fellow to integrate CI into established research projects, Global CyberBridges links the U.S. fellows with their international counterparts to work in teams. To facilitate collaboration, students and faculty have been experimenting with SAGE, a scalable, adaptive graphics environment. SAGE employs grid computing to allow researchers to run applications on a remote cluster while simultaneously streaming the process onto large tiled displays.

Expanding the scale of the project has come with its own obstacles. Beyond the sheer difficulty of time and distance, program directors have been forced to juggle different university schedules and cultural differences. For the first year, U.S. students set the research agenda and asked for their international counterparts to join the projects they found interesting. In subsequent years, they'd like for the international students to have a more active role in setting the agenda.

Global CyberBridges has received initial funding for three more years, but Alvarez isn't ruling out future adaptations of the CyberBridges model, including a U.S. model that links graduate students at universities across the nation. "What you really end up doing is teaching people how to work in a multidisciplinary environment, how to look outside of the box, how to use a technology to solve your own research problems, and how to work within teams," she said. "It's about building collaboration."

Resources

- Global CyberBridges, http://www.CyberBridges.net/: Provides access to current news, publications, and a detailed summary of the project.
- About CyberBridges, http://www.CyberBridges.net/archive/description.htm: A link to a detailed description of the CyberBridges pilot, including background research and similar projects employed by CIARA.
- Student Research, http://www.CyberBridges.net/archive/relatedpublications.htm: Provides links to student posts and PowerPoint presentations detailing their research.
- NSF CI-TEAM, http://www.nsf.gov/crssprgm/ci-team/: Provides an overview of the NSF's commitment to CI research, including current news and studies on the possibilities of CI for teaching and learning.

Endnotes

1. For a more complete description of cyberinfrastructure, see *7 Things You Should Know About Cyberinfrastructure*, http://connect.educause.edu/library/abstract/7ThingsYouShouldKnow/44951.

2. "CyberBridges is bridge to success for FIU students," http://www.cyberbridges.net/archive/bridgesuccess.htm.

3. Ibid.

4. NSF Blue Ribbon Panel on Cyberinfrastructure, "Revolutionzing Science and Engineering Through Cyberinfrastructure," http://www.nsf.gov/od/oci/reports/ExecSum.pdf, p. 1.

5. Ibid., pp. 2–4.