Cyber-Share Outcomes Report

Many of the problems that confront 21st century society are complex and require improvements in understanding that cross science and technology disciplines in synergistic ways. The Cyber-ShARE (Sharing Resources to Advance Research and Education through Cyberinfrastructure) Center of Excellence at the University of Texas at El Paso conducts research on these kinds of problems and develops a workforce that is capable of contributing to such integrated research across disciplines. Created in 2007 through a grant from the National Science Foundation Human Resource Development Division, Cyber-ShARE brings together experts in computer science, computational mathematics, education, earth science, and environmental science to advance and integrate cyber-enhanced, collaborative, and interdisciplinary education and research through technologies that support the acquisition, exchange, analysis, and integration of data, information, and knowledge. During the initial funding period, Cyber-ShARE conducted research and supported subprojects within the following three areas:

- Knowledge representation: The work in this area focused primarily on the challenge of providing information to scientists and other users of cyberinfrastructure that allows them to trust the data and products that they can automatically retrieve;
- Earth's Structure: The work in this area addressed the challenges of integrating geophysical data from diverse sources to obtain a more coherent understanding of the structure below the earth's surface that results in earthquake activity; and
- Environmental Science: The work in this area addressed issues of integrating data collected at different spatiotemporal scales (from sensors at field sites to sensors in space), to better understand the exchange dynamics and biophysical controls of land-atmosphere carbon, water, and energy exchange in several extreme environments including the Chihuahuan Desert, Arctic tundra in northern Alaska, and tropical forests in East Kalimantan on the island of Borneo.

INTELLECTUAL MERIT

The merit of the Cyber-ShARE Center lies in its success of the following: developing interdisciplinary research capacity at the University of Texas at El Paso (UTEP); educating diverse scientists and engineers who can work in interdisciplinary teams and are knowledgeable in using state-of-the-art cyberinfrastructure (CI) technologies; and developing center and institutional-level CI that can exploit and contribute to emerging national-level CI.

Developing research capacity. All projects supported by Cyber-ShARE involve faculty and student researchers from multiple disciplines. Through workshops, training, and immersion, students learn how to work in interdisciplinary teams.

In its efforts to support collaboration and use of disseminated scientific results, the researchers from the *Knowledge Representation* subproject developed software products and methods for documenting the steps of a scientific analysis from initial data collection, through processing and analysis, to publication and sharing of results. The specific outcomes of the subproject include the VisKO framework and tool that simplifies the generation of visualizations and annotates them with provenance to support reuse, the WDoIt framework and tool for representing formal knowledge about data with respect to how it is collected and transformed, and the CARP methodology for creating, annotating, refining, and publishing scientific resources. The prototype software products generated by the subproject were tested within the other two subprojects and are now being promoted for use in research efforts at the university and elsewhere.

In its effort to generate a better understanding of the structure beneath the Earth's surface, and its relationship with earthquakes, the research from the Earth Structure subproject has resulted in algorithms for the fusion of seismic data and geophysical models. Because the Earth's subsurface in earthquake-prone regions is enormously complex, data generated at different times and through different means must be integrated. The subproject has produced a novel model fusion approach to create more accurate models of Earth structures from velocity models, an angular density approach for processing seismic data that uses innovative techniques to quantify spatial resolution of the resulting geophysical model, and an optimization method that provides a robust approximated model in terms of satisfying geophysical constraints, accuracy, and efficiency. Another major effort has focused on the collection and analysis of data to determine the crustal structure of the Rio Grande Rift (RGR).

The *Environmental Science* subproject has developed new CI to improve understanding of the exchange dynamics and biophysical controls of land-atmosphere carbon, water, and energy exchange in several extreme environments. In particular, the subproject has resulted in the following: new approaches for optimizing site selection; improved capacities for data property specification and quality flagging; innovative theoretical methods for gap filling data; optimized algorithms for unmanned aerial vehicle guidance and flight planning; documented workflows and ontologies in support of knowledge capture; expanded understanding of the relationship between surface hydrology, vegetation greenness and remote sensing; cross correlation of digital elevation models derived from terrestrial LIDAR, airborne LIDAR, kite aerial photography, and satellite imagery; and an improved standard for interoperability in Web mapping applications. The data that has resulted from the project is being contributed to national and international networks and prototype software are being tested by colleagues within the field, which has generated positive feedback.

Cyber-ShARE has diversified its funding portfolio and extended the involvement of researchers in engineering, science, and the arts.

Diversifying the STEM workforce. Cyber-ShARE has funded 71 student Cyber-ShARE Scholars directly since 2007 and involves an additional 10 students leveraged from other funding sources. 54 of these are citizens or permanent residents. The ethnicity of the students who are citizens or permanent residents are as follows: 45 students are Hispanic, 1 student is African American, 2 students are Asian/Pacific Islander, and 6 students are white. Of these students 22 are female and 32 are male. Compared to the national averages for geology, environmental and computer sciences graduate students (NSF 2008), Cyber-ShARE students are 83.3% Hispanic while the national average is 4.7%, and 40.7% female while the national average is 30.8%.The first cohort of PhD students graduated in summer and fall 2011. Dr. Pearl Brazier is a professor at the University of Texas Pan American; Dr. Irbis Gallegos is a Research Assistant Professor at the Regional Cyber and Energy Security Center for Distributed Solar PV Systems; Dr. Santonu Goswani is with Oakridge National Laboratory; Dr. Leonardo Salayandia is an entrepreneur in the international manufacturing industry; Drs. Nicholas del Rio and Aida Gandara are post-docs on a NASA grant; two Ph.D. students (one of whom is female) from the computational science program have recently graduated, and one female Ph.D. student is scheduled to graduate in fall 2013. The center has graduated 15 Master's students who are now working at, for example, the Census Bureau, the U.S. Forest Service, the International Studies Abroad program, Microsoft, and Hewlett Packard; three are entering Ph.D. programs. Of the nine undergraduate students, eight have continued to Master's programs.

Developing institutional-level CI. Cyber-ShARE houses a visualization laboratory composed of a 45-monitor tiled display driven by a 360-core Linux cluster interconnected by a high-speed network and supported by technical staff. This lab is used for visualization of scientific data for

research, education, and outreach efforts. Cyber-ShARE has installed an eddy covariance tower and phenocam network to measure land-atmosphere energy and carbon and water balance at the USDA Jornada Basin Long Term Ecological Research Program, a 300 m robotic tram system that collects hyperspectral reflectance data in Barrow, Alaska, a network of seven automatic weather stations at UTEP's Indio Mountains Research Station; and a green roof and sensor testing facility at UTEP's Biology Building.

Cyber-ShARE serves as the anchor in developing the university's Expertise Connector System, which uses Semantic Web technologies to connect individual researchers and research communities based on their expertise for collaborative research. Expertise Connector has the following features: faculty and professional staff profiles; research center profiles; university published research stories that are linked to faculty and professional staff, centers, departments, colleges, university units, and research priority areas; and I^3 Move communities that assists in locating groups of people who share a common purpose around a topic.

BROADER IMPACTS

The Cyber-ShARE Center's development of CI resources, such as software tools, online services, data repositories, ontologies, and workflows has far-reaching implications for local and national research projects (e.g., NSF-funded projects such as EarthScope and NEON, both of which aim to collect multivariate data over large spatial areas, and local efforts related to energy and environment). The interdisciplinary expertise supported by the Center contributes to a robust computational science doctoral program, CI-focused curriculum, and tools that integrate research and education. By offering research experiences to students from a variety of backgrounds, providing workshops, and supporting a *Distinguished Lecture Series*, the Center contributes to the development of a diverse workforce with CI proficiency. The Center leverages existing education and outreach efforts, and its activities involve researchers from underrepresented groups outside of UTEP, extending the impact the Center.