Cyber-ShARE Annual Report

NSF AWARD HRD-0734825

THE UNIVERSITY OF TEXAS AT EL PASO

July 2009-July 2010

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Introduction

Through NFS CREST funding, the Cyber-ShARE Center of Excellence of the University of Texas at El Paso was established in 2007 to provide shared cyberinfrastructure (CI) that supports interdisciplinary research and education. The Cyber-ShARE Center brings together experts in computer science, computational mathematics, education, earth science, and environmental science. The team addresses the challenge of providing information to scientists and other users of CI that allows them to make informed decisions about the resources that they retrieve and to have confidence in using results from CI-based applications. The Cyber-ShARE team conducts innovative research to facilitate the development of CI-based applications and increase their use by scientists by enhancing CI results with provenance information, trust recommendations, and uncertainty levels (areas that are recognized as essential for the success of CI); by creating scientist-centered tools and artifacts; and by contributing CI resources to appropriate CI portals.

The **mission** of the Center is to fully utilize and advance CI with the aim of developing strong collaborative and interdisciplinary research, fostering innovation, and opening doors for a new generation of scientists and engineers who obtain advanced degrees. The center **goals** are to:

1. To create a CI-enabled synergistic environment to advance innovative and interdisciplinary research in STEM and education.
2. To train and educate a new generation of interdisciplinary, CI-knowledgeable STEM students who receive advanced degrees and represent the 21st century demographics.
3. To become nationally recognized for its CI contributions to STEM and education communities

Student Researchers

The students funded through the Center are listed in Table 1.

Table 1: Students Impacted by Cyber-ShARE

STUDENT	CLASSIFICATION	PROJECT OR ACTIVITY	ETHNICITY/CITIZENSHIP
Gallegos, Irbis Josue	PhD	Center/Environmental Science	Hispanic Resident
Ochoa Jr., Omar	PhD	Center/Geosciences	Hispanic Citizen
Olaya, Julio Cesar	PhD	Center	Hispanic International
Cerda, Ibrahim	Undergraduate	Geosciences	Hispanic International
Lopez, Andrew P.	Undergraduate	Geosciences	Hispanic Citizen
Licea, Francisco	Master's	Center	Hispanic Citizen
Nevarez, Jesus R.	Undergraduate	Center	Hispanic International
Ordonez, Maria	Master's	Center	Hispanic Citizen
Romo, Jessica	Undergraduate	Center	Hispanic Citizen

STUDENT	CLASSIFICATION	PROJECT OR ACTIVITY	ETHNICITY/CITIZENSHIP
Jaimes Hernandez, Aline	PhD	Environmental Science	Hispanic International
Brady, Jerald J	Master's	Environmental Science	White Citizen
Escapita, Irving J.	Undergraduate	Environmental Science	Hispanic International
Ramirez Garcia, Gesuri	Master's	Environment Science	Hispanic International
Quinonez, Sarah	Master's	Geosciences	Hispanic Citizen
Sosa, Uram I.	PhD	Geosciences	Hispanic International
Thompson, Lennox E.	Master's	Geosciences	African American Citizen
Del Rio, Nicholas R.	PhD	Computer Science	Hispanic Citizen
Gandara, Aida	PhD	Computer Science	Hispanic citizen
Garza, Antonio	Undergraduate	Computer Science	Hispanic citizen
Porras, Hugo	Undergraduate	Computer Science	Hispanic citizen
Esparza, Patricia	Master's	Computer Science	Hispanic citizen
Patlan, Ezer	Master's	Geosciences	Hispanic citizen
Arora, Jitin	PhD	Computer Science	International

Students who are working on Center activities and funded through other sources are as follows:

1. Avila, Natalia - Hispanic US Resident – Undergrad – Center
2. Berumen, Gloria - Hispanic US Citizen – Undergrad – Center
3. Mendez, Arely - Hispanic US Citizen – Undergrad – Center
4. Yamil Asusta - Hispanic US Citizen – Undergrad – Center
5. Herrera, Jose - Hispanic US Citizen – PhD – Environmental Science
6. Goswami, Santonu – Asian Non Citizen – PhD Environmental Science
7. Vargas, Sergio – Hispanic US Citizen – PhD Environmental Science
8. Gonzalez, Libia - Hispanic Non US Citizen – Grad – Environmental Science
9. George Walker Johnson – White US Citizen – PhD – Environmental Science
10. Christian Andresen – Hispanic US Citizen – PhD Environmental Science

In May 2010, six Undergraduate Cyber-ShARE Scholars graduated and one graduate Scholar graduated in the 2010 Summer Semester. Ivan Gris (CS), Ibrahim Cerda (ES), Natalia Avila, Arely Mendez, and Roberto Nevarez (CS) entered graduate school to pursue a M.S. degree, and Jessica Romo began a full-time career in industry.

Organizational Partners

The following organizations have partnered with the Cyber-ShARE Center over the past year.

- Aerospace Mission Corporation
- AmeriFlux
- Arctic Observing Network (AON)
- Computing Alliance of Hispanic-Serving Institutions (CAHSI)
- Circumarctic Environmental Observatory Network (CEON)
- EcoTrends
- Geoscience Network (GEON)
- Nuna Technologies
- Pan American Center of Earth and Environmental Studies (PACES)
- Sustaining Arctic Observing Networks (SAON)
- USDA Jornada Experimental Range Long-Term Ecological Research Program
- Virtual Solar Terrestrial Observatory - The National Center for Atmospheric Research (VSTO-NCAR)

Other Collaborators or Contacts

- Elizabeth Anthony, Professor, Department of Geological Sciences, University of Texas at El Paso
- Barry Benedict, Executive Director, Center Environmental Research Management (CERM), University of Texas at El Paso
- Carsten Burstedde, Postdoctoral Student, Director of Center of Computational Geosciences, UT Austin
- Cynthia Chang, Research Scientist, in the Tetherless World Constellation at Rensselaer Polytechnic Institute (RPI)
- Li Ding, Research Scientist, in the Tetherless World Constellation at Rensselaer Polytechnic Institute (RPI)
- Allison Gaylord, Nuna Technolgoies
- Omar N. Ghattas, Director of the Center of Computational Geosciences, University of Texas at Austin
- Phillip Goodell, Professor, Department of Geological Sciences, University of Texas at El Paso
- Kris M. Havstad, Supervisory Research Rangeland Management Scientist, Agricultural Research Service (ARS), United States Department of Agriculture (USDA), Jornada Experimental Range, Las Cruces, NM
- S. Kay Hunt, Manager of Customer Services, Purdue University (Campus Champion program)
- Erik J. Kappus, Department of Geological Sciences, University of Texas at El Paso
- G.R. Keller, Chair, School of Geology and Geophysics, University of Oklahoma
- Bridget Konter, Assistant Professor, Department of Geological Sciences, University of Texas at El Paso
- Jaspar Konter, Assistant Professor, Department of Geological Sciences, University of Texas at El Paso
- Scott Lathrop, Director of Education, Outreach, Training and External Relations, TeraGrid
- Deborah McGuinness, Rensselaer Polytechnic Institute (RPI)
- Kate Miller, Professor, Department of Geological Sciences, University of Texas at El Paso
- Lawrence Murr, Professor, Department of Metallurgical Engineering, University of Texas at El Paso
- Kristine Navarro-McElhaney, Director, Institute of Oral History and Regional Archives Center, University of Texas at El Paso
- Debra Peters, Research Ecologist, Agricultural Research Service (ARS), United States Department of Agriculture (USDA), Jornada Experimental Range, Las Cruces, NM

- Andrzej M. Pownuk, Assistant Professor, Department of Mathematical Sciences, University of Texas at El Paso
- Jay Pulliam, Professor, Department of Geophysics at Baylor University
- Eduardo Quinonez-Rico, Lecturer, Department of Mathematical Sciences, University of Texas at El Paso
- Al Rango, Research Hydrologist, Agricultural Research Service (ARS), United States Department of Agriculture (USDA)
- Steve Roach, Professor, Department of Computer Science, University of Texas at El Paso
- Laura Serpa, Professor, Department of Geological Sciences, University of Texas at El Paso
- Stephan Zednik, Research Associate, in the Tetherless World Constellation at Rensselaer Polytechnic Institute (RPI)
- Ann Zimmerman, Research Assistant Professor, School of Informatics Information Collaboratory for Research on Electronic Work, University of Michigan
- Taisser Y. Zumlot, 2006, Department of Geological Sciences, University of Texas at El Paso

Center and Project Activities

A. Center Activities

The Cyber-ShARE Center is a focal point for achievement of the following four strategic goals: to create a CI-enabled synergistic environment to advance innovative and interdisciplinary research in science, engineering, and education; to train and educate a new generation of interdisciplinary scientists who can effectively use CI-based software services and middleware and tools; to become nationally recognized for its CI contributions to the science, engineering, and education communities; and to become a sustainable center.

The Cyber-ShARE Center provides venues for faculty, staff, and students to collaborate. In particular, it serves as a meeting venue for numerous projects, including weekly meetings for the Center's subprojects and presentations for visitors. The Center offers workshops and other training opportunities; it supports educational and K-12 outreach activities to attract a mainly minority population to STEM fields; and it sponsors a Distinguished Lecture Series as a conduit to expose UTEP to CI-related research and education while enabling UTEP researchers and students to disseminate their results; and it provides general computing services and resources for users from UTEP and the community.

A.1 K-12 Outreach Material Development

- Dr. Gates and Leonardo Salayandia collaborated with Ms. Delia Comeau, a local high-school science teacher, to develop four curricular units for high-school students. The units are entitled "Scientific Method Exploration," "Mapping," "Magnetic Field," and "Gravitational Rotation." Each unit includes a lesson plan, a PowerPoint presentation, and a combination of planned activities with pen and paper (maps and profiles) and computer labs. The Scientific Method Exploration Lesson Plan uses Cyber-ShARE's WDO-It! Workflow creation and editing tool to teach students how to map processes that follow the scientific method.
- Dr. Giza, the Educational Lead, completed the educational activity for middle-school students entitled "Cyber-ShARE Excites Arctic Sea ICE Measurement Activity (5 E Version)." He posted the text of the activity at the following link: http://www.educationtechnologies.com/modules/ice1. This activity integrates two concepts: Web-based environmental science resources and open-source software tools to edit multimedia material. The combination of concepts engages students in learning about technology and their environment in an entertaining way. This activity empowers students with key concepts about our environment (e.g., the notion that satellite

images provide powerful evidence of the environmental impact of global warming). The activity also provides students with engaging multimedia tools for exploring computer technologies while learning science topics. Graphics editing is the "hook" that is being used to connect technology with science data sets that are available on the Internet. Students learn how to edit images with filters and quantify differences between images in a procedure that models the kind of image processing that is done in more sophisticated ways in the geosciences. The target audience is 6 - 9th grade students.

Dr. Romero and Cyber-ShARE Research Scholars prepared and delivered the following outreach activities in the UTEP campus and at regional middle schools and high schools:

- Between October 2009 and February 2010, Dr. Rodrigo Romero participated both in the promotion and on the application review process of local participants in the National Center for Women & Information Technology (NCWIT) Award for Aspirations in Computing. The goal of the project was to recognize high school girls who are involved with computers and to encourage them to enter technology-related majors in college. The top five regional participants received local awards and recognition for their achievements during a ceremony at UTEP.
- In February, 2010, Dr. Romero and Cyber-ShARE Research Scholars Cesar Chacon, Ivan Gris, and Maria Elena Ordonez participated in the UTEP's College of Engineering "Engineering Week" by giving presentations about Cyber-ShARE projects to 109 students of local high schools. This included 53 students from Chapin High School, a magnet school with a strong emphasis on attracting students to STEM fields.
- On June 7, 8, 9, 15, 21, 22, 28, 29 and 30, and on July 12, 13, and 14, 2010, Dr. Romero and Cyber-ShARE Research Scholars Ivan Gris, Gloria Berumen, Erika Ollivier, and Maria Elena Ordonez presented Cyber-ShARE projects to students who attended the ExcITES Summer Camp organized by the College of Engineering of the University of Texas at El Paso. In this camp, students from regional middle schools and high schools attended 90-minute sessions at the UTEP campus which combined presentations and hands-on activities. The CyberShARE Scholars explained the projects that the center is working on and encouraged attendees to pursue a college degree. In order to capture students' attention, the research scholars were divided into two teams to offer attendees a variety of presenters and points of view. The presentations focused on visualization and other Cyber-ShARE projects. Each team explained the core concepts of the covered projects and performed one hands-on activity (either ICE or Visualization with Paraview) with each group. At the end of each session, students were asked to answer a survey which queried about aspirations. Out of a total of 273 attendees in the month of June, after the outreach sessions the number of students interested in pursuing a college degree increased by a 67%. In addition, out of the 114 attendees in the month of July, after the outreach sessions the number of students who were very interested in pursuing a college degree increased by 53%.

A.2 Undergraduate and Graduate Course Development

CI-related courses that were created and offered at UTEP during the reported period included the following:

Professor: Vladik Kreinovich

Title: Topics in Emerging Computing Paradigms/Topics in Soft Computing: Quantum and Tensor Computing (CS 5353/CS 4365)

Description: This course provides an introduction to emerging, revolutionary computing paradigms. Topics may include quantum, chemical, and biological computing. Main objective of this particular course is to learn about the computers of the distant future: what will they look like? How to program them?

Professor: Steve Roach

Title: Software Engineering: Requirements Engineering (CS 4310/4311)
Description: A two-semester capstone project in which students work with a customer. Dr. Roach and the students worked with Dr. Craig Tweedie to develop a CyberShARE related proect.

Professor: Leticia Velazquez and Andrzej Pownuk
Title: Introduction to Computational Science (CPS 5401)
Description: A graduate□level course that presents an introduction to basic computational science skills including UNIX, scientific programming using high level languages, message passing interface, and parallel computer architectures.

Professor: Miguel Argaez
Title: Numerical Optimization **(**MATH 5345**)**
Description: A graduate-level course that includes the study of numerical algorithms for solving systems of nonlinear equations, unconstrained optimization, and nonlinear least squares problems. Derivation of necessary and sufficient conditions for constrained optimization, and an introduction to interior-point methodology.

Professor: Andrezj Pownuk
Title: Mathematical and Computer Modeling
Description: A graduate course covers the computer simulation of selected practical problems from physics, engineering, geology, biology, or chemistry. Students learn to create mathematical models, formulate modeling assumptions, select appropriate numerical methods, implement them in the form of a computer program, and visualize the numerical results. Emphasis is given to verification and validation procedures, and team-oriented training activities.

Professor: Craig Tweedie
Title: Biology (BIO 4395)
Description: Students learnt how to assess the pro's and con's associated with the use and advancement of technology in ecological and environmental science; acquired a basic knowledge of how a variety of sensors and automated data collection systems operate; learned the role of relational databases and geographic information systems in managing large or complex environmental data sets; compiled datasets and corresponding metadata, and learned how to archive these at internationally recognized data centers; demonstrated their theoretical knowledge by discussing how technology can be used to solve ecological questions; improved their awareness of the range of technological innovations being used and/or developed in the ecological and environmental sciences to solve complex real world problems.

Professor: Craig Tweedie
Title: Environmental Biology (ESE 6404/ESCI 5401)
Description: This course examines the relationship between the biological and physical environment. Topics include organismal biology, ecology, biogeochemical cycling, technology and environmental biology and current research themes and priorities in environmental biology.

Professor: Vladik Kreinovich
Title: CS 4365/CS 5354 Fuzzy Systems and Their Application to Information Assurance, Geosciences, and Environmental Sciences.

Description: Fuzzy logic techniques can be applied to transform expert knowledge, which is described in natural language, into numerical algorithms. While some of these techniques are similar to traditional probabilistic and statistical techniques used in science and engineering, some use more sophisticated approaches such as multi-valued logic. The course focuses on fuzzy logic applications in Geological Sciences, Environmental Sciences, and Information Assurance because in these areas equations and sparse data are supplemented by algorithms based on expert knowledge to carry out research. This class provided an intro to relations between uncertainty maintenance in computer science, geosciences, and environmental sciences, largely developed as a research part of the Cyber-ShARE grant.

From July 2009 to July 2010, Dr. Romero assisted efforts to create a new Certificate and MS in Software Engineering (MSSE) Program of UTEP's Department of Computer Science. Dr. Romero served as a liaison with Software and Information Technology Organization, a regional professional organization, which helped to determine regional needs for graduates of the Software Engineering Program and provided a pool of instructors for a few of the courses included in the program. In addition, he participated in meetings of the MSSE Program Board of Advisors.

A.3 Distinguished Lectures

The lectures from the Cyber-ShARE Distinguished Lecture (CDL) Series during the reporting period included the following:

Date: November 20, 2010
Speaker: Dr. Thomas G. Dietterich, Professor and Director of Intelligent Systems, Oregon State University
Title: Automated Cleaning of Sensor Network Data using Dynamic Bayesian Networks
Description: Modern sensor network technology involves large numbers of cheap sensors which are subject to high levels of noise and error and produce data streams too voluminous for manual cleaning. We are developing dynamic Bayesian network methods for modeling the joint probability distribution of multiple sensor data streams and then using this model to identify anomalies and errors in the data. The joint probability model discovers and exploits redundancy between sensors and is able to fill in missing values very accurately. We will describe results from the HJ Andrews LTER climate stations and short-term deployments of SensorScope nodes.

Date: March 25, 2010 (with Computational Science Program)
Speaker: Dr. Karl Benedict, Director of Earth Data Analysis Center, University of New Mexico
Title: Development of Standards-Based Geospatial Applications at EDAC – Perspective from 10 Years of Evolution
Description: UNM's Earth Data Analysis Center focuses on applied geospatial technologies and data in general. During the past 10 years, EDAC's work in the development of web-based geospatial applications, which began within ESRI's online mapping toolkit, evolved into a tiered model based on open interoperability standards that allow for a logical separation between geospatial data storage and geospatial data services.

Date: March 28, 2010 (with the Computational Science Program)
Speaker: Dr. John Kieffer, Professor Material Science, University of Michigan
Title: Computation in Materials Research: from Interpretation to Prediction
Description: Increased computer speed and new algorithms have advanced computational materials research from a means to merely interpret experimental data to a tool for the design and discovery of novel materials. Examples illustrating this evolution will be presented that include the explanation of anomalous thermo-mechanical properties of network glasses and the development of a numerical framework for the rapid screening of organic semiconductor molecules in view of identifying the most promising candidates for photovoltaic or solid state lighting applications, before these are synthesized and tested in the laboratory.

Date: May 19, 2010 (with the Computational Science program)
Speaker: Dr. Carsten Burstedde, Institute for Computational Engineering and Sciences, The University of Texas at Austin
Title: Parallel adaptive mesh refinement for solid earth geophysics problems
Description: Many problems in solid earth geophysics are characterized by dynamics occurring on a wide range of length and time scales, which complicates the numerical solution of the governing partial differential equations (PDEs). Adaptive mesh refinement (AMR), which can resolve spatio-temporal scales and features of interest, promises to overcome the challenge of modeling multiscale problems. However, the benefits are difficult to achieve in practice, particularly on highly parallel supercomputers. Due to complex mesh topology and communication patterns, and frequent data exchange and redistribution, scaling dynamic AMR to tens of thousands of processors has long been considered a challenge. Additional difficulties are encountered when extending parallel AMR techniques to high-order-accurate, complex-geometry-respecting finite element methods that are favored for many classes of solid earth geophysical problems. We present the ALPS (Adaptive Large-scale Parallel Simulations) framework for parallel adaptive solution of PDEs and describe applications to selected solid earth geophysics problems: global mantle convection with nonlinear rheology and global seismic wave propagation.

Date: June 30, 2010 (visitor)
Speaker: Zarrin Langari, PhD Candidate David Cheriton School of Computer Science University of Waterloo
Title: Formal Modeling and Verification using Graph Transformation Systems
Description: Formal modeling is a crucial first step in the analysis of mission critical communication protocols, such as IP telephony, which are notoriously resistant to formal modeling and verification. Modeling the Distributed Feature Composition protocol, we found that graph transformation offers several key advantages over naive methods in modeling the dynamic evolution of a reactive communication protocol. Graph transformation semantics enables a clean separation of concerns when describing a protocol, which is key for dealing with even modestly sized protocols. In this talk, I show how GTS modeling can facilitate verification of invariant properties of potentially unbounded communication systems. Verifying an ordering among these service components to be invariant is essential to guarantee the desirable behavior of these services. The verification can be performed by the analysis of a finite set of transformation rules describing the GTS system model and while invariant properties are preserved in a GTS model.

A.4 Workshops

CyberShARE offered workshops on topics related to high-performance computing and visualization. The Cyber-ShARE Center serves as a CI resource for UTEP and professionals, students, and organizations from the regional community. As a member of TeraGrid's Campus Champion Program, CyberShARE offers training and technical consulting on topics related both to resources in the Center and resources at TeraGrid service providing organizations. UTEP also served as a hosting site for the Virtual School of Computational Science and Engineering summer course "Big Data for Science." A description of the workshops is provided under "Training and Development."

A.5 Resources and Support

Resources and support provided by Cyber-ShARE are described below:

- In May 2010, Dr. Tweedie and the students from the environmental science sub project team hosted a class from Arizona State University for a field trip to Eddy tower and tram system on the Jornada Experimental Range.

- Dr. Romero collaborated with Dr. Phillip Goodell of UTEP's Department of Geological Sciences and Dr. Taisser Zumlot to develop a website that provides geochemistry data of New Mexico for professional experts, researchers, students, and the community. This website will serve as a template to present geochemistry data for other states as well.
- Dr. Romero and Cyber-ShARE Research Scholars Julio Olaya, Jessica Romo, and Gloria Berumen built a 20-monitor tiled-display visualization test bed as a training environment for researchers and students interested in working with an ultra-high resolution display system.
- The Center is provided computing resources and technical support for the research project entitled "N-body simulations of spheroidal systems using NEMO" by Hector Noriega-Mendoza from UTEP's Physics Department and Luis A. Aguilar from the Institute of Astronomy of the National University of Mexico at Mexico City. This project uses NEMO, a stellar dynamics toolbox, to study the pure gravitational evolution of large and massive spheroidal systems (including elliptical galaxies and dark matter halos) formed through dissipationless collapse and mergers. In addition to NEMO, the project will use gyrfalcon, a powerful, high-precision N-body code to simulate systems with a large number of particles. The hardware/software platform will be used to perform simulations of millions of particles.
- Cyber-ShARE provided computational resources to Dr. Juan C. Noveron, from UTEP's Department of Chemistry, to run Molecular Dynamic Simulations using the "Desmond" software application under "Maestro" from the Schrodinger Company; computational cluster access and technical assistance were given to Murat Durandurdu from the Physics Department and Eduardo Quinonez from the Mathematical Sciences Department; CyberShARE committed to work on visualization projects with Dr. Chuan Xiao in connection with his NSF CAREER proposal for a project to combine cryo-electron microscopy and X-ray crystallography to study the structure of a giant marine virus; and CyberShARE supported Dr. Larry Murr's submission of the DARPA proposal entitled "Development of Novel Materials/Materials Systems With Controlled Microstructural Architecture (Mcma) Fabricated By Additive Manufacturing Using Electron Beam Melting."
- A new 30-meter resolution Shuttle Radar Topography Mission (SRTM) was added to the previously obtained 90-meter SRTM dataset collected by NASA. Both data sets contain globally collected topography data of the Earth. Users of these datasets include students in UTEP's classes in the Geological Sciences department, including Volcanology and GIS class, who use these data to create maps of their research areas.

A.6 Other Activities

- Cyber-ShARE in collaboration with the NSF BPC Computing Alliance of Hispanic-Serving Institutions provided a Research Experience for undergraduate student Yamil Asustao from the University of Puerto Rico Mayaguez. He worked with other students to design, implement, and evaluate the performance of CUDA kernels to compute first arrival travel times of seismic waves for three-dimensional seismic tomography applications.
- On December 8, 2009, The Cyber-ShARE PIs and Senior Personnel held a meeting with the Center's Steering Committee Meeting attendance – Anny Morrobel-Sosa, Dean College of Science, Richard Schoephoerster, Dean College of Engineering, Josefina Tinajero, College of Education, Roberto Osegueda, Vice President of Research, and Richard Jarvis, Provost.
- On February 8, 9 & 10, 2010, the Cyber-ShARE Center researchers and staff participated in the NSF-sponsored Building Partnerships and Pathways to Address Engineering Grand Challenges Conference, hosted by the College of Engineering of The University of Texas at El Paso.

- February 2010 NSF Highlight - Development of Cyberinfrastructure to Support Ecological Research in the Chihuahuan Desert. This Center highlight document was used as a good example of how to design and what to include in a highlight document for CREST during the NSF 2010 JAM.
- On May 1, 2010, The Cyber-ShARE PIs, Senior Personnel, and staff held a retreat to review and complete the strategic plan of the Center.
- During the report period, Dr. Romero and Cyber-ShARE Scholars Natalia Avila, Gloria Berumen, Maria Elena Ordonez, and Francisco Licea finished the Paso del Norte Entrepreneurship Oral History Project (www.heho.utep.edu) in collaboration with Dr. Irasema Coronado of the UTEP's Kauffman Campus Initiative and Kristine Navarro-McElhaney of the Institute of Oral History. Oral interviews of 36 entrepreneurs with their transcripts, mp3 recordings, and related newspaper articles are currently posted at the website. During the report period, the www.heho.utep.edu website had 11,770 page loads, 3,706 total visitors, 2,913 first-time visitors, and 793 returning visitors. The website was used for class assignments for CHIC 4307 – Hispanic Entrepreneurship (3-0), an examination of Hispanic entrepreneurship in the United States that includes the culture, language, social dynamics, demographics and business opportunities of Hispanic communities. In this course, the student will analyze entrepreneurship, business ownership, features of marginal and formal business ownership, and be introduced to the formal business process.
- In 2010, Cesar Chacon, a Cyber-ShARE Undergraduate Research Scholar, enhanced and migrated the website of the Materials World project, which is located at http://materialsworld.utep.edu, to a Cyber-ShARE server. The Development of Materials World Modules (MWM) for Undergraduate Science was led by Dr. Michael Eastman, a professor of UTEP's Department of Chemistry, and supported in part by the U. S. Army Research Laboratory and the U.S. Army research Office under Contract W911NF0410052. In 2004, UTEP and Morehouse College joined the MWM project to develop inquiry-based curricula for science and non-science major students at freshman/junior level. During 2010-2011 participants in the "UTEP Cycle 3: 2009-2011, Mathematics, Science and Technology Teacher Preparation Academy" will use this material as part of their preparation. The Academy is funded by a grant from the Texas Coordinating Board. The Cyber-ShARE website for Materials World will be initially used for 2010 Summer Workshops.

B. Subproject Activities

The research focus of the **subproject 1(Computer Science)** is to gain users' confidence in workflow execution results by enhancing results with provenance information, trust recommendations, and levels of uncertainty. This subproject addresses provenance, trust, and uncertainty about the results of cyber-infrastructure-based applications. Drs. Pinheiro da Silva (lead), Gates, Kreinovich contributes to the goals. The activities of this subproject are summarized below.

In the second year, the CS subproject team started implementing systematic semantic enhancements to geo-science and environment science processes with the goal of improving the problem-solving capabilities of these processes. The enhancements are part of the subproject goal of working closely and collaboratively with geoscientists and environment scientists to simultaneously accomplish the following objectives:

1. To understand how scientists tackle scientific problems, and in particular, how they develop, execute and improve complex processes to solve those problems;
2. To expose scientists to semantic and cyber-infrastructure technologies that have the potential of overcoming known limitations of the current scientific processes;
3. To indentify key enhancements that can better support solving the problems identified in (1);

4. To develop tools that can be used to create and maintain artifacts in support of enhancements identified in (2); and
5. Using the proposed enhancements in (3) and the tools in (4), to collaboratively work with scientists to enhance their complex processes.

These objectives have driven the activities within the group and have led to documenting selected scientific processes. A goal is to establish a new Cyber-ShARE-way of enhancing these scientific processes with semantic information, the CI-Miner approach, and to develop human resources in other scientific fields capable of replicating and disseminating the use of semantic technology.

The processes that were documented with semantic enhancement are as follows:

- Hole's Code – Earth science/seismology
- Reflectance Data Gathering – Environmental science
- Eddy covariance data processing – Environmental science
- 2 ½ D crustal structure of the Earth – Earth science
- National Center for Atmospheric Research (NCAR) CHIP Quick Look Process – Solar physics

Another direction focused on developing new (and faster) algorithms for processing uncertainty related to cyber-infrastructure, where different data points come with different information about their uncertainty (e.g., probabilistic, interval, and fuzzy). More efficient algorithms have been developed for processing uncertainty, especially uncertainty related to cyber-infrastructure, where different data points come with different information about their uncertainty.

The goal of **subproject 2 (Geosciences)** is to determine the physical properties of the Earth by advancing data fusion of distinct information sources and by studying and developing techniques and approaches for integrating data with varying accuracy and sensitivity. Drs. Velasco (lead), Velazquez, Argaez, and Kreinovich contribute to the goals. The faculty and students involved in the project represent a wide range of disciplines: geosciences, computational mathematics, and computer science.

The Geosciences team continues to meet weekly with a diverse group of students and faculty to discuss research progress and direction. Out of these weekly discussions, the team has initiated activities, such as working groups for data sharing across disciplines and projects, the development of ontologies in geophysics, the development of workflow driven ontologies in geophysics, and the production of documents to explain processes and research topic that will be understandable to students and scientists in all three disciplines in the project. The weekly review is the foundation for the collaboration, and the team has gained insights that have led to innovations in the research.

The Geosciences team have made presentations and attended national and international meetings, including: SIAM, 13th GAMM-IMACS International Symposium on Scientific Computing, National Mathematical Congress in Columbia, the Annual Fall Meeting of the American Geophysical Union, 2010 Annual Conference of the Computing Alliance of Hispanic-Serving, and the Society for the Advancement of Chicanos and Native Americans in Science.

The goal of subproject 3 **(Environmental Science)** is to address the challenge of optimizing data streams and sensor arrays in ecological and environmental networks through case studies targeting improved characterization of environmental phenomena and processes. Collectively, this effort includes faculty and students who represent the following disciplines: biology, environmental science, geosciences, computational science, electrical and computer engineering, and mathematics. Members of this subproject meet weekly and include approximately equal numbers of student and technician attendees funded on non-CREST projects. Meetings focus on the presentation of student and

faculty research and discussion focuses on interdisciplinary problem solving that facilitates further development of the research. Subproject research collaborators meet separately to the weekly group meetings. These opportunities for cross-disciplinary communication and exchange of ideas have facilitated this subproject tremendously and a range of novel research activities have been developed as a result.

Research results have been presented at multiple national and international meetings; several software applications and web services have been launched and or are undergoing prototype testing; external collaborations with several government and industry partners have been established; a major field installation of environmental sensors has been completed; and the roof of the biology building at UTEP has been renovated as a green roof space suitable as a sensor testing platform.

Specific activities related to subproject 3 over the past year include:

- Further development of an eddy covariance tower (partnered to Ameriflux), robotic tram system (partnered to SpecNet), phenocam system (partneres to the National Phenology Network), wireless sensor network and remote power and communication system. This site is now part of the unmanned aerial vehicle monitoring program orchestrated by the USDA ARS field office. The site has also been visited by multiple groups:
    - Conference participants of the "Back to the Future" NSF-funded land cover change project, November 2009.
    - Field class from Arizona State University, May 2010.
    - Jornada Symposium participants, July 2010.
- Development of an unmanned aerial vehicle for low altitude environmental science data capture. This system now integrates GPS, intervolometer, still and video camera systems and a range of operational-related metrics linked to a ground based monitoring station.
- A kite aerial photography system has been developed. This system incorporates similar technologies to those developed for the unmanned aerial described above but avoids complications associated with the Federal Aviation Authority.
- Documentation of work flows and data specification and quality flagging tools suitable for implementation on the robotic tram system and eddy covariance tower.
- Phenocam software that can automatically images of remote field sites, define areas of interest and then quantify the spectral properties associated with these images. This system is being implemented on the phenocam network at the Jornada Experimental Range, the unmanned aerial vehicle and the kite aerial photography system.
- A range of new widgets for web based mapping systems have been developed. These include capacities to extract web services, integrate data in an online environment, review descriptive statistics for given datasets and conduct simple correlations.

Findings

A. Subproject 1: Computer Science

A.1 Scientific Collaborations

For subproject 1 (Believing and Accepting Cyber-Results) led by Dr. Pinheiro da Silva, the work was focused on building scientific communities over cyber-infrastructure by enabling sharing of data and semantic-related annotations over the Web. This was done with the design and implementation of the CI-Server, CI-Client API and CI-Desktop. This year we setup the first CI-Server in Drupal and offered the first CI-Client API in Java. This framework has two

important features, first, a server is enhanced to manage resources and provide services allowing for access to content without dependence on knowing the Website's structure, i.e., the culture of the Website, and two, scientific applications can be instrumented to access resources from CI-Servers allowing scientists to work together in the tools they are accustomed to using. The team built and offered, via the CI-Server Website, the first CI-Desktop for accessing CI-Server resources and publishing resources. The first client tools were instrumented with the CI-Client API, e.g. VisKO, WDOIt! and WDOIt! Data Annotator. These tools were originally used to create artifacts preserved on individual workstations and this enhancement allows for immediate sharing and reuse of information between scientific communities.

Another effort resulted in WFTalk!, an interface for sending comments about workflows to the CI-Server, and the tool was embedded it in WDOIt! The initial CI-Server interface was enhanced as an exercise to identify CI-Server functionality that should be available within the pages of CI-Server compatible servers; without imposing this on the culture of the Website. A backup utility was tailored and shared over the CI-Server Website focused on building one-off versions of CI-Server; allowing for individual development or test environments and facilitating the replication of CI-Server sites. A test tool was built to test CI-Server services at different sites. This tool has been added to the CI-Server toolset as a regression test and a mechanism to guarantee CI-Server compatibility for new sites. Initially, all provenance was published in the form of static Proof Markup Language (PML) nodes, we are able to build pml-person nodes dynamically using user content found within the CI-Server. (PML is a provenance Interlingua rooted in proof theory concepts.) Overall, this work has resulted in a workshop paper accepted at The Computer Supported Collaborative Work: Changing Dynamics of Scientific Collaboration Workshop 2010, a workshop paper accepted at The International Provenance and Annotation Workshop 2010, a poster at Grace Hopper Celebrating Women in Computing 2009, a poster at The Computing Alliance of Hispanic Supporting Institutions Conference 2010, and a poster at The Computing Research Association-Women 2010 Grad Cohort.

In relation to the work done understanding how scientists work together and in particular as a result of creating the CI-Server framework, the following will discuss the findings within the past year. Understanding what needs to be provided within the CI-Server framework helped establish the framework's three primary goals: enable sharing of information, building community and discovering new knowledge based on the semantic content available at the server. Through the publication of PML and the building of PMLP provenance we learned that given the content of a content management server, the server can provide both static and dynamically built provenance, facilitating some of the provenance gathering. Since one of the initial goals of this research was to help scientists share, we were not focused on trying to build 'that ONE server'. This research has allowed us to focus on understanding how to replicate the CI-Server model and how to test those models to make servers and thus server content more interoperable. CI-Server is a framework that can be embedded into Websites, making it easier to share information seamlessly from within scientific applications without having to understand the culture of the Website. Still, we found it important to identify and provide CI-Server related content that can be embedded in the Website content. To continue to support the needs of managing content with the culture of a Website, administrators should be able to decide how and where to embed this information so that it still aligns with the Website's culture. Allowing scientists to discuss resources from within the tools they are accustomed to using is beneficial to supporting the work of a scientific community. Nevertheless, we have learned that it is not sufficient to just send and read messages about a resource; we need to provide useful views about a resource and groups of resources that support the discussion context. Without this, the comments have less relevance on teamwork.

A.2 Process Knowledge Capture

A tool called WDO-It! is being developed to allow scientists document their processes in the form of abstract workflows. Abstract workflows provide a graphical notation that facilitates authoring and interpretation by users and that does not require specialized or highly computer technical expertise. Having explicit documentation about the processes that scientists follow to conduct their work is an initial step towards building cyberinfrastructure in support of the sciences and education. Over the last year, efforts have resulted in the documentation of several processes from scientists involved in Cyber-ShARE. Specifically, abstract workflows have been created for the following processes: 1) Hole's code seismic tomography, 2) Crustal modeling through the use of receiver functions, gravity data, and magnetic data, and 3) Eddy Covariance data capturing and processing to monitor Carbon emission fluxes in the environment.

From using the abstract workflow specifications documented to reflect a scientist's interpretation of their processes, another ongoing effort is to annotate scientific data related to those processes with metadata, i.e., data about data, to document provenance. Functionality of the CyberShARE portal is being extended to allow scientists to upload their data in a consistent way to reflect their processes documented as abstract workflows. The intention is to support the share of scientific data over the web such that others can discover and analyze that data based not only on what the end products represent, but also on how those end products were produced, which methods were used, and what people were involved.

During the process of modeling scientific processes in collaboration with domain experts, we realized that the domain experts often deal with processes that are carried out in very diverse environments and systems that can range from manual procedures to sophisticated software/hardware tools. In this context, we confirmed that abstraction is a powerful mechanism to hide system complexity so that emphasis is placed on the target scientific problem domain instead of the tools used. Abstract workflows show promise as a practical tool to exploit abstraction for sciences and education.

By using the holistic approach of the World Wide Web where everything can be referenced through a Uniform Resource Identifier (URI), our approach to implement Abstract Workflows has been revisited to include references to provenance attribution things. In this way, process specifications and descriptions can be grounded in terms of people involved in executing a process and the types of methods and information sources they use. Initial prototypes of our tools and their application to the scientific domains involved in Cyber-ShARE suggest that the end result will be a scalable solution for scientists to describe their processes, their data, and their outcomes in a way that can be reused across disciplines.

A.3 Provenance Knowledge Capture

Data annotation refers to a technique of automatically documenting provenance information associated with scientific processes. Driven by Semantic Abstract Workflows (SAW), our data-annotation system generates sets of modules that are tailored for capturing key activities in some scientific process and documenting the execution of these activities in PML. Because of the expressiveness of PML, our data annotators are capable of describing the inputs that fed into a workflow activity, its outputs, and any meta-information about the processing step, possibly including a description of the algorithm. Our past efforts have focused on developing data-annotators that can target a wide range of scientific processes or pipelines including those based on workflow technologies such as Kepler and processes that use scripts to orchestrate execution. The following is a list of additions that we have made to the data annotator over the past year:

- Enhanced the WDO-It! tool to include a "wizard-type" user interface for users to configure the Data-Annotator module generation. From this wizard, users can specify what processing system they are targeting (e.g., Windows batch scripts, Unix shell scripts, or Kepler) and whether or not the process is human-driven.
- Leverage CI-Server to provide a centralized public location from which to dump the PML documents.
- Reuse concepts defined in the WDO to tag provenance elements captured in the PML docs. This effectively links the provenance captured in the PML documents to the concepts defined by the users of WDO-It!

PML is a provenance Interlingua rooted in proof theory concepts and as such has been found to be difficult for users to generate "high quality" PML traces in scientific domains. This is likely due to the fact that the richness of the language and making it sometimes difficult for users to map the proof like vocabulary to a scientific setting. Our data-annotator has alleviated this concern by allowing user to work with PML indirectly. In fact, users rarely have to work with raw PML because our toolset has become mature enough to accommodate the provenance needs' of users of many scientific disciplines including solar astronomy, geophysics, and environmental science.

Another important finding was the impact made from linking the provenance information to the concepts defined in the workflow. This link allows us to query for provenance in terms of the workflow vocabulary, rather than querying in terms of the PML language. Once again we allow provenance users to work in an environment in which concepts are defined by themselves.

A.4 Provenance Queries

The SPARQL-PML activity aims to provide insight to how provenance information can be queried and searched. Since PML is based on RDF and OWL, this activity leverages the SPARQL query language that is designed for querying RDF data stores. I have focused on two tasks during this past year. The first has been to create a RDF store and populate it with the provenance information that has been generated by the group so far. Access to this store is provided through services and enables members of the group to query and retrieve specific information from this store, which in turn enables and enhances some functionality in tools produced by other members of this group. This step involved several challenges and provided useful insights. The first step was the selection of a suitable store and reasoner.

The second step was the implementation of a web interface aimed at making it easier for scientists to easily query and search for information in the aggregated provenance store. The implementation of this web interface led to the identification of several queries that answer frequently asked or important provenance related questions. During this step, issues of performance began to appear. This has led to the current focus on quantifying query performance and identifying bottlenecks with the goal that this will lead to insight on scalability of this approach, and potentially, suggestions for updating the PML ontologies to improve query execution times for important or frequently asked questions.

During the search for an appropriate triple-store for Cyber-ShARE, it was discovered that due to the specifics of PML encoding, a form of reasoning known as property chaining is needed to answer useful provenance related queries. Property chaining was standardized by the W3C in October 2009 as part of OWL and a reasoned implementation supporting this standard became available the next month. The PML-SPARQL ontology was developed as an adjunct to the PML ontologies to support the querying of provenance information. This step also involved a technology related challenge. It brought to light that the group was using outdated tools for implementing and consuming services, and led to a significant effort to understand and implement services based on recent standards. Upgrade of tools was also required.

B. Subproject 2: Geosciences

The Geosciences subproject (Integrated Analysis for Development of 3-D of Earth Structure) has made progress on various efforts that have allowed for fruitful collaborations and innovative technical breakthroughs. Through a strong collaboration between scientists and computer scientists, we have developed ontologies and workflow-driven ontologies for seismic and mathematical components of the project. We have also developed "modular" documents that are meant to describe fundamental processes and science issues for the project in a language that is understandable across disciplines. The first such document, 1-D Velocity Model Development, demonstrates the key concepts behind modeling and was written by a computational science student.

The subproject team has taken two different approaches for attaining its objective of developing 3-D velocity models of the Earth derived from multiple data sets. The first approach focuses on merging the output of modeling individual data sets. This approach, which we call model fusion, takes into account the resolution of the model and the errors associated the analysis. The second approach is to develop a theoretical framework for inverting multiple data sets. This approach will take longer to develop and implement. Both approaches are working at different ends of the problem. Model fusion focuses on the outputs, and the inverting multiple data sets focuses on the input.

The results of the computational scientists, who are working in collaboration with scientists, include the following:

- Proved that a related notion called the quasi-central path, while being a less restrictive notion, is sufficiently strong to guide the iterates towards a solution of the problem.
- Developed an optimization code for John Hole's Algorithm for solving a 3-D seismic travel time tomography problem and produce a more accurate model of the Earth. The expected code will offer the use of restrictions in material properties and parameters by applying Interior-Point Methods.
- Investigated two global optimization strategies combined with three parameterization schemes that can be applied for solving large scale parameter estimation problems.
- Modified a reconstruction method based on Reweighted Normal Equations (RNEs); observed that the modified RNEs had reduced computational complexity, both in terms of number of iterations and computation time.
- Showed an algorithm that is capable of working efficiently to recover the reflection coefficients from seismic data in the area of seismic reflection and separating two speakers in a single channel recording in the audio separation problem.
- Implemented a primal-dual interior-point method to solve an inverse seismic wave problem. We compare the numerical behavior of the logarithmic barrier, primal-dual interior-point (IPM), projected conjugate gradient, and primal-dual active sets methods for solving one-dimensional partial differential equations constrained optimization problems arising on earthquake applications.

C. Subproject 3: Environmental Science

Subproject 3 (Advancing the Utility of Cyberinfrastructure in Environmental Science) has held weekly meetings and group discussions on a range of research and other activities in the environmental sciences. The team has developed use-case scenarios that have been used to develop work flows, software, and web services for interacting with a range of environmental sensors, analyzing collected data and visualizing these in a web based environment. Field instrumentation focused on improving knowledge of land-atmosphere carbon, developing a water and energy budget, and developing a backend cyberinfrastructure.

In addition, the team has designed, engineered, and flight tested an unmanned aerial vehicle. An instrument package for this has been developed and is undergoing field testing.

The Cyber-ShARE Center has facilitated the development of workflows, software and web services, engineering faculty have facilitated the development of research infrastructure and instrumentation; domain focused researchers have proved use case scenarios and all of these have been fully documented. These research products will form key platforms for future research foci.

Specific findings and outcomes of subproject 3 over the past year include:

- Automated data collection, transmission and server-ingestion of data from the eddy tower, sensor network and phenocam system has been implemented, optimized, and specified. Our success has appears to have overcome challenges encountered by other researchers.
- Data collection with the unmanned aerial vehicle has been initiated, allowing transition to the development of optimization tools for this system.
- The Arctic Research Mapping Application (ARMAP – www.armap.org) web mapping software designed won 3rd place at the 2009 ESRI International User Conference in the "*Best Web-Based GIS Application*" category.
- Won ESRI's overall most popular ArcGIS explorer blog post for 2009 for the development of the Arctic Research Mapping Application (ARMAP) in ArcGIS Explorer (http://blogs.esri.com/Info/blogs/arcgisexplorerblog/archive/*2009/12/30/top-explorer-blog*-posts-for2009.aspx?utm_source=feedburner&utm_medium=feed&utm_campaign=
- Feed%3A+ArcgisExplorerBlog+%28ArcGIS+Explorer+Blog%29).
- Prototype web mapping applications and associated decision tools have been developed with
- collaborators at New Mexico State University and the Border Environment Cooperation Commission. Initial review suggests these applications have the potential to greatly improve decision making.
- Prototype ontologies, workflows and data quality flagging tools have been developed for the eddy covariance tower and robotic tram system. Recent reviews by colleagues outside of the development team suggest these products can provide much needed input to the greater community. In particular, we have developed a data property categorization for experimental readings and experimental conditions and a prototype tool for assisting practitioners in specifying and refining data properties that capture expert scientific knowledge.

Other Accomplishments

The following is a list of accomplishments of the investigators and Center:

- In July 2010, Co-PI Dr. Craig Tweedie accepted an invitation to become a Co-PI of the USDA Long Term Ecological Research (LTER) Program on the USDA Jornada experimental range near Las Cruces, NM. The LTER program is currently the largest ecological research network in the United States with 26 sites across the country, Puerto Rico, and Antarctica. The invitation was based on the work accomplished by the team of Dr. Tweedie's Cyber-ShARE subproject at their relatively new site on the JRN. His participation in the LTER program opens the door to new collaborations, additional expertise in Environmental Science, and network resources including bibliography, GIS layers, remote sensing imagery, IM tools, etc. In addition, his participation in the LTER program enables his team to further the adoption of their technologies and software to other users throughout the US involved in the LTER and affiliated programs.
- Co-PI Dr. Aaron Velasco was awarded a $2.9 million NSF Graduate Teaching Fellows in K-12 Education Grant for the proposal entitled "Science for a Sustainable Future: Developing the Next Generation of Diverse Scientists," which will strive to attract minorities to STEM fields. Graduate students funded by the fellowships from this award will support teachers and students participating in the El Paso's Early College High-School

science. Fellows will help to develop curriculum materials and provide mentorship to students. US southwest issues related to water resources, alternative energy sources, population growth and health, and geological hazards will be presented to students as tangible scientific challenges to encourage them to enter STEM fields of study.

- In March, 2010, the Cyber-ShARE Center started to work on a formal collaborative agreement with New Mexico State University at Las Cruces' Center for Research Excellence in Bioinformatics and Computational Biology (BCB). Given the complementary nature of their missions and goals, both centers will provide summer internships to faculty and graduate students. While Cyber-ShARE will provide training on cyberinfrastructure tools and technologies, BCB will provide training on software applications for bioinformatics. Dr. Ann Gates and Dr. Enrico Pontelli, the directors of the Centers, expect to provide two internships per year at each Center.
- PI Dr. Gates in collaboration with Dr. Ann Zimmerman, an assistant professor of the School of Information of the University of Michigan (MSI) received a supplement for a "CREST Partnership Supplement: Establishment of a Collaboration on Digital Curation between the CyberShARE Center of Excellence and the University of Michigan School of Information's Collaboratory for Research on Electronic Work (CREW)". The collaboration will leverage Dr. Zimmerman's expertise in data curation, the activity of managing data from their point of creation to ensure that they are available for discovery and reuse in the future, and sought funding to transfer this knowledge from CREW to Cyber-ShARE. The main efforts of the project include realizing a comparative study to understand Cyber-ShARE's needs and add to CREW's knowledge of scientific data practices, providing Cyber-ShARE internships to UM-SI Master's students who would develop a data curation strategy for Cyber-ShARE, and offering a data curation workshop to disseminate the Cyber-ShARE experience in data curation and scientific process documentation to a broader community of researchers. Dr. Zimmerman's would also serve as a liaison between the OpenData IGERT and Cyber-ShARE and helping to arrange exchanges with UTEP students.
- In October, 2009, Dr. Rodrigo Romero was appointed as the IEEE Computer Society co-representative to the Coalition to Diversify Computing, a joint organization of the Association for Computing Machinery, the Computing Research Association, and the IEEE Computing Society.
- In September, 2009, Dr. Craig Tweedie opened the Cyber-ShARE Sensor Testing facility on the roof of UTEP's Biology building – the first green roof in El Paso, TX. The purpose of the facility is to develop and test sensor technology for Environmental Science research and to support education-related activities. This facility provides free 24/7 access for students, researchers and faculty who need a secure and/or outdoor facility for conducting research or teaching-related activities focused on the development and deployment of sensor technologies
- In September, 2009, Dr. Rodrigo Romero from the Cyber-ShARE Center, Dr. Virgilio Gonzalez from the Department of Electrical and Computer Engineering, and Drs. Jasper Konter, Bridget Konter, and Jose Hurtado from the Department of Geological Sciences received a $699,671 NSF Award for the project entitled "MRI: Acquisition of the Cyber-ShARE Collaborative Visualization System (C2ViS)." The central component of C2ViS is an ultra-high resolution tiled-display system which will be located in the C2ViS visualization laboratory. Planning is finished and work has started to expand the Cyber-ShARE facilities to accommodate the C2ViS laboratory, personnel, and graduate students in addition to more Cyber-ShARE Research Scholars. The additional facilities measure over 3400 sq. ft. and are located in a high-visibility area of the UTEP campus. The C2ViS laboratory will enable local and virtual scientific collaborations, use of scientific visualization for research and education, and research in visualization using ultra-high resolution displays.

Training and Development

The Cyber-ShARE Center offered the following workshops and training opportunities to UTEP and the regional community:

- In the Fall 2009 and Spring 2010 semesters, Dr. Romero, Cyber-ShARE Scholars Julio Olaya and Francisco Licea, and Cyber-ShARE Research Specialist Leonardo Salayandia prepared and delivered workshop/lecture sessions for the Computational Science Course CPS 5401—Introduction to Computational Science. The eight workshops on cyberinfrastructure offered on both semesters are the following: "Linux for new users," "C Programming (Introduction)," "C Programming (Advanced)," "Linux Shell Programming," "Computer Architecture and Networks," "Parallel Programming Introduction with MPI," "Parallel Programming with MPI," and "Data Interoperability through Ontologies." Considering both times the topics were covered, each workshop reached an average of 24 mostly Ph.D. students from UTEP's Computational Science Program attended the workshops.
- March 30 (Software Engineering class), April 2 (Environmental Sciences group), and May 19 (Computational Math group) at San Jose, CA. Leonardo Salayandia presented the WDO-It! 101 workshop. This workshop reviewed the basics of creating Semantic Abstract Workflows (SAWs). SAWs are useful to formalize your understanding of a process and communicate it to others in a graphical format. Furthermore, SAWs can be used to analyze systems that are used in support of your process so that they can be customized to better fit the intentions of your process. After completing this workshop, attendees will be able to use the WDO-It! tool to create SAWs about processes that you use in your every-day work.
- In July 26 – 30, 2010, Cyber-ShARE, UTEP's Computational Science Program, and UTEP's Department of Computer Science in collaboration with NMSU's NSF CREST Center for Research Excellence in Bioinformatics and Computational Biology co-sponsored UTEP to be a hosting site of the Virtual School of Computational Science and Engineering (VSCSE) for the summer course "Big Data for Science." VSCSE was created as a result of the Blue Waters Project – an NSF-funded collaboration between NCSA and IBM. The course covered cutting-edge techniques and technologies, such as cloud computing, semantic web, and visualization, which are critical for dealing with the enormous digital data sets generated by research activities in various fields including Astronomy, Bioinformatics, and Earth Science. Dr. Romero was the organizer and moderator of the course at UTEP, and Cyber-ShARE Ph.D. Research Scholar Julio Olaya and Julio Garcia, the C2ViS research specialist, were the local teaching assistants for the course presentations and hands-on activities. A total of 27 attendees including 14 Ph.D. students, six M.S. students, four undergraduate students, and three research staffers participated in the course.

Outreach Activities

Dr. Romero and Cyber-ShARE Research Scholars prepared and delivered the following outreach activities in the UTEP campus and at regional middle schools and high schools:

- Between October 2009 and February 2010, Dr. Rodrigo Romero participated both in the promotion and on the application review process of local participants in the National Center for Women & Information Technology (NCWIT) Award for Aspirations in Computing. The goal of the project was to recognize high school girls who are involved with computers and to encourage them to enter technology-related majors in college. The top five regional participants received local awards and recognition for their achievements during a ceremony at UTEP.
- In February, 2010, Dr. Romero and Cyber-ShARE Research Scholars Cesar Chacon, Ivan Gris, and Maria Elena Ordonez participated in the UTEP's College of Engineering "Engineering Week" by giving presentations about

Cyber-ShARE projects to 109 students of local high schools. This included 53 students from Chapin High School, a magnet school with a strong emphasis on attracting students to STEM fields.

- On June 7, 8, 9, 15, 21, 22, 28, 29 and 30, and on July 12, 13, and 14, 2010, Dr. Romero and Cyber-ShARE Research Scholars Ivan Gris, Gloria Berumen, Erika Ollivier, and Maria Elena Ordonez presented Cyber-ShARE projects to students who attended the ExcITES Summer Camp organized by the College of Engineering of the University of Texas at El Paso. In this camp, students from regional middle schools and high schools attended 90-minute sessions at the UTEP campus which combined presentations and hands-on activities. The CyberShARE Scholars explained the projects that the center is working on and encouraged attendees to pursue a college degree. In order to capture students' attention, the research scholars were divided into two teams to offer attendees a variety of presenters and points of view. The presentations focused on visualization and other Cyber-ShARE projects. Each team explained the core concepts of the covered projects and performed one hands-on activity (either ICE or Visualization with Paraview) with each group. At the end of each session, students were asked to answer a survey which revealed that, out of a total of 273 attendees in the month of June, after the outreach sessions the number of students interested in pursuing a college degree increased by a 67%. In addition, out of the 114 attendees in the month of July, after the outreach sessions the number of students who were very interested in pursuing a college degree increased by a 53%.

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Posters

Argaez, Miguel; Quintero, Carlos; Gomez, Javier; Kreinovich, Vladik; Salayandia, Leonardo; Velasco, Aaron; and Velazquez, Leticia, "On Optimization Techniques for the One-Dimensional Seismic Problem presented

Brady, Jerald, "Development of an Unmanned Aircraft system (UAS) for Environmental Scientists", at the 18th Symposium of the Jornada Basin Long Term Ecological Research Program at New Mexico State University and the USDA, Agricultural Research Service, Rangeland Research Unit based at the Jornada Experimental Range, Thursday, July 15, 2010, in Las Cruces, New Mexico

Chacon, C., Licea, F., Olaya, J., and Romero, R., "STg: Cyberinsfrastructure for Seismic Travel Time Tomography," Proceedings of the 4th Annual Meeting of the Computing Alliance of Hispanic Serving Institutions, CAHSI 2010, April 5-7, 2010, Redmond, Washington.

Gallegos, Irbis; Goswani, Santonu; Tweedie, Craig; Gamon, John and Gates, Ann, "A Runtime Data Verification Cyberinfrastructure for an Automated Robotic Tram System Measuring Surface Reflectance in the Arctic". Proceedings of the CAHSI 4th Annual Meeting, April 2010, MicroSoft, Richmond, Washington.

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Hussein, Musa; Velasco, Aaron A.; Doser, Diane L. and Serpa, Laura F., "Crustal Structure of the Salton Trough: Integration of Receiver Functions, Gravity, and Magnetic data"

Jaimes, Aline, "Net Ecesystem Exchanges of Carbon, Water and Energy in Creosote Vegetation cover in Jornada Experimental Range" 18th Symposium of the Jornada Basin Long Term Ecological Research Program at New Mexico State University and the USDA, Agricultural Research Service, Rangeland Research Unit based at the Jornada Experimental Range, Thursday, July 15, 2010, in Las Cruces, New Mexico

Jaimes, Aline; Tweedie, Craig E.; Peters, Debra C.; Herrera, Jose and Cody, Ryan, "GIS-tool to optimize site selection for establishing an eddy covariance and robotic tram system at the Jornada Experimental Range (JER), NM"

Jaimes, Aline; Tweedie, Craig E.; Peters, Debra C.; Ramirez, Gesuri; Brady, Jerald; Gamon, John; Herrera, Jose; and Gonzalez, Libia, "A New Site for Measuring Multi-Scale Land-Atmosphere Carbon, Water and Energy Exchange at the Jornada Experimental Range"

Ochoa, Omar; Velasco, Aaron A. and Kreinovich, Vladik, "A Fast, Practical Alternative Towards Joint Inversion of Multiple Datasets" Proceedings of the CAHSI 4th Annual Meeting, April 2010, Microsoft, Redmond, Washington.

Olaya, J.C., and Romero, R., "Visualization of Inversion Uncertainty in Travel Time Seismic Tomography," Proceedings of the 4th Annual Meeting of the Computing Alliance of Hispanic Serving Institutions, CAHSI 2010, April 5-7, 2010, Redmond, Washington.

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Sosa, Anibal; Velazquez, Leticia; Burstedde, Carsten; Argaez, Miguel and Ghattas, Omar. "Numerical Comparison of PDE Constrained Optimization Schemes for Solving Earthquake Modeling Problems", presented at SIAM's Annual Meeting poster session on July 2009 at Denver, Colorado.

Sosa, Anibal; Velazquez, Leticia; Velasco, Aaron; Argaez, Miguel and Romero, Rodrigo, "A Study of Regularization and Interior-Point Methods for Optimizing Joint Inversion of Geophysical Datasets" presented at SIAM's Annual Meeting poster session on July 2010 at Pittsburgh, Pennsylvania

Contributions to Scientific Networks

The following contributions have been made to scientific networks:

- Geochronos earth observation portal (http://geochronos.org/) – a data and information system for the Spectral Network (SpecNet). http://specnet.info/.
- Johnson, G.W.; A.G. Gaylord, J.J. Brady, M. Dover, D. Garcia-Lavigne, W.F. Manley, R. Score, and **C.E.** Tweedie, 2009. Arctic Research Mapping Application (ARMAP). Englewood, Colorado USA: CH2M HILL Polar Services. Digital Media. http://www.armap.org. More than 20 web services are available through ARMAP.
- Tweedie, C.E.; A.G. Gaylord. 2009. The Circumarctic Environmental Observatories Network. DVD, Online. http://www.ceoninfo.org

Web/Internet Site and Other Products

The Cyber-ShARE website is http://cybershare.utep.edu . Other specific products include:

- Prototype semantic wiki installation: http://rio.cs.utep.edu.
- Software, Ontology and Workflow Development
    - Barrow Area Information Database (BAID, www.baidims.org):
        - *BAID-Internet Map Server* (production) – allows GIS-interactivity with more than 646 data and information layers, including more than 9000 research sites dating back to the 1940's.
        - *BAID for Google Earth* (production) – allows BAID research site data to be viewed in Google Earth.
        - *BAID Instrument Browser* (production) – allows map visualization and interactivity with informational and other data associated with more than 350 instruments in the Barrow area in northern Alaska.
        - *Barrow SAR viewer* (production) – allows map visualization and interactivity with near real time space-borne synthetic aperture radar acquired for the Barrow area.
    - Arctic Research Mapping Application (ARMAP, www.armap.org):

- *ARMAP-Internet Map Server* - allows GIS-interactivity with more than 750 data and information layers, including more than 10,000 locations associated where US Federally funded research has taken place since the late 1990's (Production).
- *ARMAP for Google Earth* (production) – allows ARMAP data to be viewed in Google Earth (production).
- *ARMAP for ArcGIS Explorer* – allows globe visualization and interactivity with ARMAP data (production).
- *ARMAP-Flex application* – allows querying and visualization of the ARMAP dataset to show, for example, trends in US federal research expenditure for different fields of arctic research (beta).

- Circumarctic Environmental Observatories Network (CEON, www.ceoninfo.org):
  - *CEON-Internet Map Server* - allows GIS-interactivity with more than 120 data and information layers (production).
  - *CEON for ArcGIS Explorer* – allows globe visualization and interactivity with ARMAP data (prototype).
  - *CEON-Flex real time data tool* – allows visualization of near real time data from >2000 climate stations, >500 webcams, and earthquake observatories in the arctic (beta).
  - *Unmanned Aerial Vehicle specification, operation, and control software* – allows UAV platform and sensor specification, flight planning and data collection optimization and recording (beta).
  - *Site choice tool* - a Geographic Information System processing routine that uses a series of parameterized decision and optimization algorithms to identify and prioritize site selection for ecological and environmental research and instrument placement (prototype).
  - *Pheno-cam control and analysis system* – a program that captures manual or timed images from webcams, allows definition of areas of interest in these images, splits the image in to red, green and blue spectra and analyzes these to quantify plant and landscape phonological development (prototype).[1]
  - *Spectral library* (www.spectrallibrary.utep.edu) – allows reflectance in the visual and near infra-red spectra to be queried and plotted in an online environment (production).
  - *Border Environment Cooperation Commission (BECC)/ Comisión De Cooperación Ecológica Fronteriza (COCEF) mapping application* – built in a Flex environment to allow visualization of BECC/COCEF supported projects along the US-Mexican border (beta, http://arctic.utep.edu/becc/prototype/).
  - *Data Property Specification (DaProS) tool* – walks scientists through a series of guiding questions and selection options allowing the user to identify appropriate data categories and specifications that the tool then represents in a natural language validation purposes (prototype). This tool will be further developed to allow for rapid comprehensive flagging of data quality in real time data streams. [2]

[1] This software has been developed as collaboration between environmental science students and Geovany Ramirez and Gesuri Ramirez, graduate students in Computer Science at UTEP.

[2] This tool was developed by Irbis Gallegos (PhD student, Computer Science) under the supervision of Ann Gates and with the collaborative support of Leo Salayandia (Computer Science graduate student) and Aline Jaimes from the environmental science subproject.

- *Near-real time data verification monitor* – uses a near real time data stream from a dual channel spectrometer that measures reflectance in the visual and near infra-red wavelengths and flags poor quality data (prototype). [3]
- *Ontology and workflow for describing the eddy covariance process* – an ontology and series of workflows that describe the micrometeorological, atmospheric physics and applied mathematical procedures utilized for computing land-atmosphere exchange of carbon, water and energy using the eddy covariance method (prototype). [4]

- SAWServer, workflow content management server: Tool for publishing Workflow-Driven Ontologies (WDOs), Semantic Abstract Workflows (SAWs) and other workflow-related documents on the web. Tool initially designed to work via services and now migrating to Drupal to take advantage of an established open-source tool that provides collaborative features like user management and blogs
- Abstract workflow editor for workflow-driven ontologies:
  - WDOIt! workflow editor development: Tool for creating work-related ontologies including terminology and workflows. Development, help with design of general features and fixes and specifically implemented concept renaming, bookmarking, some drag-n-drop features and workspace support. We are in the process of preparing for first release including development of test cases and software web deployment.
- Tool deployment through Java Webstart
  - Probe-It! provenance visualization at http://trust.cs.utep.edu/probeit/
  - WDO-It! editor at http://trust.utep.edu section on
- Uploaded artifacts, PML-P and PML-J documents to make them web-accessible:
  - Earth science: http://iw.cs.utep.edu/earthscience
  - Environmental science: http://iw.cs.utep.edu/environmentalscience
  - Solar physics: http://iw.cs.utep.edu/astronomy

Contributions

Within the Discipline

The contributions of the project within the discipline include:

- The definition of conceptual workflows that are enhanced with semantic information to document scientific processes and facilitate understanding, discussions, and dissemination of knowledge.
- The Web-based mapping and information systems from the Environmental Science group gives domain researchers new search and analytical capabilities,
- The field instrumentation at the Jornada LTER fills a critical research gap in the AmeriFlux, SpecNet networks
- The UAV that has been developed is one of only a few focused on measuring environmental processes and phenomenon in the U.S.
- The kite photography system offers an alternative to obtaining low altitude landscape level imagery without the complexities associated with gaining FAA approval for unmanned aerial vehicles.

[3] Development of this software was spearheaded by Irbis Gallegos a PhD student in Computer Science advised by Dr Ann Gates and Santonu Goswami, a UTEP ESE PhD student advised by Dr. John Gamon at the University of Alberta and Dr Craig Tweedie.

[4] Development of this ontology and workflow was spearheaded by Leo Salayandia (CyberShARE staff member and PhD student advised by Dr Ann Gates Dr Paulo Pinheiro) and Aline Jaimes, an ESE PhD student advised by Dr. Tweedie.

- New ways of describing technological development and innovation in the form of ontologies and workflows have been developed and offer the community alternate examples for technically describing their scientific approaches and technologies.
- The model fusion approach that the Geosciences team is working may allow for fundamental shifts in how geoscientists work with data in developing Earth models. Furthermore, this approach may be used in other areas of geophysics where multiple data sets are collected, such an earthquake rupture imaging.
- Aline Jaimes, an ESE PhD student, found the limitations in existing techniques to select an optimal location for the meteorological Eddy tower, and she developed a novel methodology for solving multi-optimization problems under constraints. This methodology can be applied to multi-objective decision making problems outside environmental sciences.

The contributions in the area of uncertainty include the following:

- Begun development of a unified integrated approach to different types of uncertainty based on the ideas of symmetry
- Developed new techniques for estimating accuracy and spatial resolution of the results of processing seismic data
- Refining a model fusion approach with application in Earth sciences
- Provided improved versions of clustering algorithms under fuzzy uncertainty, versions based on dynamical systems ideas
- Provided new faster algorithms for estimating the amount of information and risk and for performing convolution and Fourier transform under uncertainty

Other Disciplines

The environmental subproject has been invited to beta test several new software packages from ESRI. They have shared code and web services with the CH2 M Hill Polar Services, the National Snow and Ice Data Center and the Global Change Master Directory. The National Weather Service and NOAA use our real-time climate tool to improve weather forecasting in the El Paso area.

The work that is being done on the CS subproject is being transferred to National Center for Atmospheric Research (NCAR) CHIP Quick Look process. In particular, knowledge gained from working on the Hole's Code workflow was transferred to the CHIP Quick Look workflow. A difference was that the NCAR scientific team desired to use the workflow to facilitate the discussions of their existing Quick Look processes in order to implement new ones. For them, such ability would make it easier to propagate the design to new implementations. Thus, the expectations and discussions in this project were focused more on how to use the workflow once it was created, as well as the capture of provenance. To address this, workflow orchestration was enhanced to generate a corresponding PML document that captures provenance information about the data produced during module execution. In addition, the Probe-It! Tool has been used in solar astronomy to visualize provenance associated with images of the corona, exposing all the details that went into generating these images including process traces and information about the data sources. If some anomaly was apparent in the coronal pictures, then scientists could use Probe-It! to trace through the provenance and identify where in the process an error might have been introduced.

Techniques for processing uncertainty that have been developed as part of this project have been successfully applied to the following areas:

- Chemistry, where we came up with a new simplified version of a method for predicting properties of chemical substances, a method of use in synthesizing new materials and new medicines
- Economics, where we came up with a new way to relate two existing approaches to decision making: utility theory and risk measures
- Engineering design, where new techniques for design under probabilistic and interval uncertainty have been developed
- Quantum computing, where we developed techniques for gauging reliability of uncertain data

Techniques for processing uncertainty that have been developed as part of this project have been successfully applied to the following areas:

- To control where new algorithms have been developed to take into account monotonicity in intelligent control under uncertainty;
- To electrical engineering, where we came up with new techniques for arc detection under uncertainty;
- To decision making and financial engineering, where new methods of handling uncertainty and estimating risk have been developed, in particular, methods that avoid restrictions imposed by Arrow's impossibility theorem; in some cases, these methods lead to a new justification of the existing heuristic techniques;
- To physics, where uncertainty comes from the partial character of our knowledge; we came up with new ideas of solving inverse problems under uncertainty;
- To signal processing, where efficient methods of data processing and Fourier transform under uncertainty have been developed;
- To social sciences, where we gave a new explanation that diversity improves the problem-solving ability of a group;
- To transportation engineering, where we justified the current semi-heuristic techniques of handling uncertainty of the drivers' behavior [K4], and developed new efficient algorithms.

The research on hybrid optimization algorithm has applications to other disciplines. A challenging problem in some real world applications is finding a global minimum (an optimal solution) for highly nonlinear problems. These problems usually appear in PDE-constraint optimization which results from applications in earthquake, recuperative of reservoirs, find oil, and medicine, among others. The procedure consists in three fundamental phases. In the first phase, a stochastic algorithm is implemented to find a region(s) where we conjecture the optimal solution can be. In the second phase, each region is modeled by a smooth quadratic function and some equality and inequality constraints are associated which represent some characteristic of the region and also some physical properties of the problem. Finally, our primal-dual algorithm is implemented to obtain a local solution in each region. The optimal solution is determined by the point that produces the minimum value of the objective function.

Human Resources

The active collaboration between members of the three Cyber-ShARE projects that integrates knowledge from geosciences, computer science, mathematics, environmental science, and engineering is probably one of the most important contributions to the development of human resources. Through involvement in these projects, the Cyber-ShARE Center is preparing the next-generation scientist and engineer who can work on multi-disciplinary teams and who has an understanding of cyberinfrastructure. The professional development workshops that provide training in cyberinfrastructure middleware and high performance computing, the outreach components that involves students in

activities that include technology and science, and the courses that reach future teachers are critical to human resource development. In addition, students are exposed to cutting-edge technologies and concepts that are not typically introduced in the curriculum, and students are able to practice and hone their skills in a real application.

Cyber-ShARE promotes the involvement of students in development workshops, preparation for graduate studies, scientific symposia, and mentoring. Students have these experiences at the university and through conferences, e.g., AGU, Computing Alliance of Hispanic-Serving Institutions, and SACNAS.

Resources for Research and Beyond STEM

Through the Cyber-ShARE portal, researchers have access to tools, data, and educational modules. The project has contributed to research infrastructure development as follows:

- 2009-Present. Eddy tower, robotic tram system, sensor network, phenocam network, remote power supply and wireless communications at the USDA Jornada Experimental Range, New Mexico. This infrastructure has been supported by a supplement from the NSF funded Cyber-ShARE Center of Excellence at UTEP.
- 2009-Present. Network of seven automatic weather stations at UTEP's Indio Mountains Research Station. These stations were co-developed with Vanessa Lougheed who has a graduate student working with data from this network.
- 2009-Present. A Green roof and sensor testing facility on the roof of the Biology Building at UTEP. This facility was catalyzed by the NSF-funded Cyber-ShARE Center of Excellence and was developed with the support of UTEP Facilities.
- 2009-Present. A growth cabinet with a series of 11 microcosms for experimenting with plant and soil monoliths to understand controls of ecosystem processes. This system includes a range of wireless and wired micrometeorological sensors and an open path trace gas analysis system with programmable solenoid valves to control airflow to each microcosm. This infrastructure was built for the IPY-BTF project with support from the Cyber-ShARE Center of Excellence.
- 2009-Present. A paraglider unmanned aerial vehicle (UAV). This remote control UAV is low and slow flying and controlled by line-of site remote control. The aircraft allows for an hour of flight time and a payload of approximately 15 kilograms. This infrastructure was developed through UTEP's Cyber-ShARE Center of Excellence and in collaboration with Industry (Atair Aerospace, http://www.atair.com/).
- 2009-Present. A 20-monitor tiled-display visualization test bed as a training environment for researchers and students interested in working with an ultra-high resolution display system
- 2007-Present. A lab for the design, prototyping, testing and manufacture of sensors, field equipment and other hardware for ecological and environmental research (700 sq ft). This lab includes a walk-in double cold room and a large workshop that houses a range of power and machining tools, systems for the development and testing of electrical circuitry, and a range of building materials and spare parts.