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CI-TEAM Implementation Project:

Global cyberbridges

A Model Global Collaboration Infrastructure for e-Science between US & Int'l Partners

Center for Internet Augmented Research and Assessment (CIARA)

CIARA
research • collaboration • scholarship

at Florida International University

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Project Summary

Cyberinfrastructure (CI) is not being fully leveraged by minority serving institutions to enhance science and engineering research and education. **There exists significant knowledge about network and computational IT innovations at Florida International University, the largest Hispanic minority-serving institution in the Continental U.S. There has however been a schism between this community and the majority of academic disciplines. Faculty members have established a *modus operandi* that is tailored to foster domain excellence. CI professionals are actively engaged in advancing applications and the science of CI. These applications are not effectively expanding the horizons for researchers and educators. The CI professionals lack a rich understanding of the domains they are targeted to serve. Faculty members are thus unable to see the full scope of opportunities enabled by CI.**

As a demonstration project 'CyberBridges' **provided a new model for the research workforce to develop a competency in using CI. CyberBridges was not a locus for fundamental CI research; it instead helped create a new generation of scientists and engineers who are capable of fully integrating CI into the whole educational, professional, and creative process of their diverse disciplines.** ***The CyberBridges demonstration project will manifest in a multi-disciplinary research paper and presentation by the students at Supercomputing 2006.***

<u>Intellectual Merit</u>

The hypothesis **that evolving graduate student education to include a foundation of understanding in *research and education CI* to bridge the divide between the information technology communities and the disciplines, has yielded encouraging preliminary results, provides the basis for intellectual merit. This concept and the publishing of encouraging preliminary results has lead to a global community coalescing around the CyberBridges model. This global community is prepared to implement.**

<u>Broader Implications</u>

We propose Global Cyber Bridges, a U.S. implementation of **multinational effort to improve the technology training for a new generation of scientists, and to increase the rate of discovery for all domains. The project has committed participation from the Chinese Academy of Sciences, the City University of Hong Kong, and the University of Sao Paulo. This collaboration adds a multiplying effect to the knowledge of cyberinfrastructure that CyberBridges brings to the graduate students, and thus research across all domains. The larger the number of graduate fellows collaboratively building their understanding in research and education CI, the greater the number of CyberBridges centers, and the greater the opportunities are for cross discipline communication.**

We are poised to succeed **because of the expertise of the investigators, the commitment of the institutions, the clarity of the plan of work, and the positive demonstration project. The research scientists involved at FIU have substantial experience managing projects of this scale, and track records of success in both the CI community and as technical advisors to graduate students. The faculty investigators have demonstrated leadership in their respective fields, and will ensure the academic integrity of the computer science and pedagogy employed. FIU views CIARA's CyberBridges as a key part of institutional improvement, and is committed to its long-term success. Genuine enthusiasm is spread across the faculty, students, and administrators, involved in proposing CIARA's Global CyberBridges.**

C. Project Description

C.1 Overview

A significant challenge continues to exist in widening the scope of deployment, adoption, use, and impact of Cyberinfrastructure (CI). We propose Global CyberBridges (GCB), a global deployment and implementation project led by Florida International University's (FIU), Center for Internet Augmented Research and Assessment (CIARA), to "***revolutionize who can participate, what they can do, and how they do it*** (NSF 06-548)**"**. The GCB project is proposed as a bridge between the CI research community and the U.S. and international science communities. It builds upon the findings of Cyber-Bridges, a 2005 CI-TEAM demonstration project[1] that is creating a new generation of minority scientists and engineers capable of fully integrating CI into the research, education, professional, and creative processes of scientific disciplines. The Global CyberBridges (GCB) project builds upon the experience of the CyberBridges, and establishes a base of sustainability through geographically expanding participation, and widening the number of academic domains involved from four to fifteen. It is designed to create a network of scientists and researchers that spans six research institutions spread over four regions and three countries: USA, China, Hong Kong, and Brazil. The Rationale for the GCB Project; its objectives and their relationship to NSF CI-Team objectives; and its activities and deliverables are described in sections C.1.1, C.1.2, and C.1.3.

Traditionally, CI researchers (usually computer science tool-builders and key research scientists) have been active in developing broadly applicable cyberinfrastructure. The CI researchers work with scientific research communities closest at hand (often physicists, astronomers, biologists, etc.) in an attempt to transfer the Cyberinfrastructure from their labs to active research networks that form part of the National Cyberinfrastructure. They work to ensure that CI is accessible, and to maintain low barriers for its adoption and use.

Often the early adopters of CI, the scientists and engineers, discover potential benefits of CI in their research domains, and thus become active in the communities that use CI. However, these early adopters are an exception. Previous CI efforts have tried to work with these early adopters to identify potential evangelists for CI in various domains of science. Such efforts, as they have relied primarily on the curiosity and enthusiasm of a few, without having a system for institutionalization and substantive rejuvenation, have not had a broad or deep impact (Cambre 1991; Pournelle 1994). A majority of scientific researchers currently do not perceive the relevance of Cyberinfrastructure for their own research. Realization of such applicability, often, requires an in-depth understanding of both their scientific domain as well as the promise of CI. Scanning other domains for possible benefit and collaborations, is often suggested, but usually too much of a time burden, and often the technical solutions are difficult to apply in a collaborative socio-technical[2] domain (Hazemi, etc. 1998).

On the other hand, CI researchers, while they are institutionally well-positioned to help the potential scientist-users of the Cyberinfrastructure, often lack the domain expertise (in sciences and engineering) to explain how CI may benefit the domain scientists in their investigations. Moreover, being developers of technology and builders of tools, often the CI researchers are not comfortable with the socio-technical issues of technology adoption, diffusion, and use. Thus, issues of implementation success are frequently given inadequate attention, and the potential benefits of CI are seldom realized at their potential due to the paucity of adoptions.

The Global CyberBridges project is designed to address this problem of inadequate adoption and use of Cyberinfrastructure. It integrates the technical cyberinfrastructure with the socio-technical design principles and the concepts of coordination globally distributed R&D, with the domain expertise of research faculty members. It thus seeks to integrate CI into global collaborative research projects today by piloting a lifelong framework of understanding for tomorrow's researchers. It does so by integrating CI in grand challenge science and globally

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[1] NSF Award # OCI-0537464, www.cyberbridges.net

[2] The term "socio-technical" recognizes that most collaboration systems involve collaborations between people using technology as an enabler. Thus the design of the system includes joint optimization of both the technical elements and socio-organizational elements of the system. Focus on technical design, with inadequate attention to the design of socio-organizational components and processes, usually results in non-adoption, non-use, and often implementation (as opposed to technical) failures of the systems. Socio-Technical Systems Theory (Mumford, 2000) is a subset of overall socio-technical systems design concepts.

distributed research projects, through published ongoing assessments of the GCB's effectiveness, and by developing an effective, research-grounded, institutional model of support. It is a project designed to affect sustained transfer of CI knowledge to a broader community of scientists and researchers. It thus builds directly towards the objectives of the NSF CI-Team Program to create a generation of current and future researchers who are well-versed in and comfortable with the deployment, adoption, and use of the CI for creating global research collaborations.

The "collisions of ideas" that Bruce Alberts, President of the National Academy of Sciences and a member of the Boyer Commission, identified as requisite to faculty and student success, is the core tenet of CyberBridges (Boyer Report, 1998, p. 11). CyberBridges is a framework for developing a workforce of scientists and engineers that will explore ways to advance their domains, aided by CI.

Using the basic building blocks of technology, technology dissemination pedagogy, and management, we propose developing 'Global CyberBridges (GCB)'; ***A Model Global Collaboration Infrastructure for e-Science between US and International Partners***. The goals of the project are to help increase the rate of discovery for U.S. science faculty and PhD graduate students by empowering them with Cyberinfrastructure, which can help them leverage the **I**ntellectual, **I**T, and **I**nstrumentation (**I3**) resources on a global scale. Global CyberBridges has not been developed to be a locus for fundamental CI research. It offers the potential of creating a global community of scientists and researchers capable of collaborating with their counterparts across the globe by fully integrating Cyberinfrastructure into their educational, professional, and creative processes. Thus, the project will include the development, integration, deployment, and testing of both the technical infrastructure, as well as the coordination, workflow, and social protocols needed for cross-cultural/cross-national collaboration.

We propose to assess the effectiveness of Global CyberBridges using a number of quantitative and qualitative measures since not all projects utilize cyberinfrastructure in the same way. For example, (1) porting applications to clusters for speedups (including tools for easily queuing hundreds of jobs); (2) utilizing improved algorithms, such as adaptive meshes, particularly if coupled to clusters; (3) using advanced databases rather than flat files; (4) exploiting high-speed networks and tools such as GridFTP to move large data volumes; (5) harnessing parallel file systems to simplify the use of disk storage; (6) utilizing Grid technologies to provide distributed computing capability. We will also assess based on broader criteria to include critical success for building communities – increased interaction between scientists, increased rate of joint research projects and joint working papers, number of joint PhD's supervised, using Fourth Generation Evaluation (Guba, 1989) of the various stakeholders. Assessing a number of success factors recognizes that not all research ends up in publications. Additionally, when collaboration is starting between cross-cultural strangers it may take a while for the collaboration to mature to a point where publications can be measured. So focusing on publication volume as the key evaluation criteria is too narrow a metric.

The underlying hypothesis is that augmenting the scientists and researchers skill-set to include a foundation in using research and education CI will bridge the physical divide across nations, thereby bringing more I3 resources to bear on science. This will result in an improved socio-technical[3] research support system for the exploration, analysis, and discovery.

Our first project will partner CIARA (Center for Internet Augmented Research and Assessment) at Florida International University in the U.S. and the Computer Network Information Center (CNIC) of the Chinese Academy of Sciences in China. Complimentary participation includes the City University Hong Kong and the University of Sao Paulo, Brazil. Global CyberBridges (GCB) proposes a new model for developing a network of researchers, scientists, and engineers collaborating across global distances in advancing discoveries. The initial focus of the proposed project is to develop, demonstrate, and institutionalize the use of cyberinfrastructure across the U.S. and China, with Brazil and Hong Kong adding depth to the distributed collaborative learning aspects of the program. The existing advanced ICT-based collaboration agreement and infrastructure for joint supervision of PhD students, between City University of Hong Kong and University of Science and Technology China will provide a prototype test-bed for experimenting with the Global CyberBridges concepts and technologies in a relatively controlled

[3] In organizational development, socio-technical systems (or STS) is an approach to complex organizational work design that recognizes the interaction between people and technology in workplaces (http://en.wikipedia.org/wiki/Socio-Technical_Systems)

environment before moving it to a broader and more diverse set of participants. Once successfully institutionalized, the results can be ported to collaborations across additional regions and disciplines.

Broader Implications: Preliminary results from work done by FIU's CIARA CyberBridges demonstration project and in various e-Science communities indicate that the above hypothesis has great potential for broad impact. At the core of the proposal is an opportunity for bringing together a global network of scientists, faculty members, and graduate students currently distributed across global distances. While the initial results of the CyberBridges demonstration project at FIU are encouraging in a culturally diverse, yet relatively homogeneous, U.S. environment, the next challenge of the concept is to port it to a global environment. The benefit of moving from a homogeneous to a global collaborative environment is to build a foundation of e-Science experience for U.S. faculty, students and researchers. However, the move to a global collaborative environment opens up additional issues of cross-cultural adjustment and coordination, workflows, social protocols that would need to be designed to build a global community of scientists. The proposed GCB project will help in two ways – First, it will develop a body of experience, guidelines, and theory that will be useful in designing global research communities in the future. Second, it will also help build such collaboration between scientists from three nations with very different cultures, traditions, and infrastructures. Furthermore, we will be developing a community – as a proof of concept – and while building this community we will also create a body of knowledge that will be useful for building future e-Science communities.

Florida International University's CIARA leads the U.S. part of the collaboration. CIARA is currently engaged in a pilot project under the NSF CI-TEAM program solicitation to further test the hypothesis with four science and engineering graduate students. FIU is the largest Hispanic minority serving institution in the continental U.S. and CIARA holds grant awards from the NSF for its work with the advanced networking and e-Science communities in Latin America and the Caribbean. Alvarez and Ibarra will provide leadership and coordination within the U.S. and between the international partners for GCB. Professor Kuldeep Kumar of Florida International University (who is currently visiting at City University of Hong Kong and working with City University's doctoral student collaboration initiative with University of Science and Technology China) will provide key coordination and liaison between the U.S., Hong Kong, and China. In addition, Prof. Kumar's extensive research on the management of Globally Distributed Work will provide the conceptual underpinnings for creating a globally distributed community of scientific researchers. Dr. Chi Zhang, Assistant Professor in Computer Information Science, at FIU leads the grid computing and high-performance networking curriculum development and delivery, along with Dr. S. Masoud Sadjadi.

The Computer Network Information Center (CNIC) of the Chinese Academy of Sciences (CAS) has significant capability to foster the GCB program lead by Prof. Yan, Bao Ping, who as director for eight years has been instrumental in providing an advanced networking infrastructure for science research throughout China and internationally. Her expert team includes the deputy director, Prof. Jun Li and the associate researcher/ executive director of the Networking Technology and Applications Research Laboratory of CNIC, Dr. Nan Kai. Dr. Nan will lead the project management of GCB, including overall coordination responsibilities within China.

The City University Hong Kong researchers bring into the GCB collaboration (a) Deep expertise in development and deployment of collaboration support systems (Doug Vogel, Information Systems Chair Professor); (b) The potential of providing a physical, technical, and cultural bridge with China; (c) its existing institutionalized agreements, research collaboration, and a mature joint PhD student supervision relationship with USTC (University of Science and Technology, China); and (d) A deep research relationship with FIU developed through the long-term visit to City U by Prof. Kumar and three shorter visits by Julio Ibarra and Heidi Alvarez.

The University of Sao Paulo (USP) and the Fundação De Amparo À Pesquisa Do Estado De São Paulo (FAPESP) of Brazil are significant collaborators with CIARA through the AMPATH, CHEPREO, and WHREN-LILA projects which are co-funded by the NSF and FAPESP. The "School of the Future" of the University of São Paulo, Brazil's largest and most productive center of higher education, is an interdisciplinary laboratory investigating the question of how the new communications technologies can improve learning at all educational levels. The School of the Future has significant experience and resources to foster the GCB program in Sao Paulo, Brazil, led by Prof. Frederic Michael Litto. Started in 1989 as a departmental laboratory in the School of Communications and Arts, its growth and increasingly interdisciplinary nature has flourished to become the School of the Future of the University of Sao Paulo.

We have high confidence of success because of the expertise of the investigators, the commitment of the institution, the clarity of the plan of work, and the positive preliminary results. The research scientists involved at

FIU have substantial experience managing projects of this scale, and track records of success in both the CI community and as technical advisors to graduate students. The faculty investigators have demonstrated leadership in their respective fields, and will ensure the academic integrity of the computer science and pedagogy employed. FIU views CIARA's CyberBridges as a key part of institutional improvement, and is committed to its long-term success. Genuine enthusiasm is spread across the faculty, students, and administrators, involved in proposing CIARA's CyberBridges. The chances of success are improved considerably because of a shared understanding of the goals of GCB by the key members of the collaboration, because the partners have already invested time achieving common ground through the development of Memoranda of Understanding[4].

C.1.2 Rationale: WHY Global CyberBridges?

A key goal of NSF CI-Team program is to develop a generation of researchers who can effectively use the Cyberinfrastructure for developing and sustaining global collaborative research networks. The ambition of the CI-Team program is to help increase the rate of discovery by empowering the scientists with cyberinfrastructure that will help them leverage the I3 resources on a global scale. The underlying premise is that the endeavor of science and discovery is too large for individual scientists and laboratories to advance rapidly without distributed collaborative efforts. Continuous interchange of ideas and ongoing collaborations across national and global boundaries are needed to address fundamental research issues in phenomenon such as Astronomy, Bio-Diversity, Epidemiology, and High-Energy Physics for example. Moreover, the "collision of ideas" envisaged by Bruce Alberts, and the resulting creative tension inherent in diversity, needs to be harnessed to increase the rate of innovation and discovery (Boyer Report, 1998, p. 11).

In recent years, the U.S. National Science Foundation and its counterparts in various regions of the world, have invested in developing the technical cyberinfrastructure for collaboration between scientists and engineering researchers around the globe[5]. Typically, this investment includes the development and implementation of advanced telecommunication networks, grids, and collaborative software environments. However, in addition to A2A (application to application – or software-to-software) and P2A (person-to-application) collaboration, e-Science collaboration often takes the form of ICT-enabled P2P[6] (person to person) collaboration (Dumas, van der Aalst, and ter Hofstede 2005, p.14). This in turn requires the availability of robust P2P collaboration technologies, well structured coordination mechanisms, and commonly agreed upon socio-organizational collaboration protocols (Kumar, van Fenema, and von Glinow 2005, 2006).

The current initiatives in developing cyberinfrastructure have focused primarily on building collaboration technologies such as broadband, synchronous tools that allow video conferencing, instant messaging, multi-point desktop and whiteboard sharing, large document sharing, and integrating email archiving. As the previous section suggested, there is considerable evidence that these technologies have not been adopted and used to their fullest potential:

> "Such service-oriented approaches to science are already being applied successfully, in some cases at substantial scales, but much more effort is required before these approaches are applied routinely across many disciplines. Grid technologies can accelerate the development and adoption of service-oriented science by enabling a separation of concerns between discipline-specific content and domain-independent software and hardware infrastructure." (Foster, 2005).

For successful adoption and use of these technologies, these efforts need to be complemented with the development and implementation of appropriate coordination mechanisms and socio-organization collaboration protocols and their dissemination to the scientific community through tailored education and training. The adoption and use of CI is further complicated by the fact that collaborations between globally distributed researchers are subject to a variety of global "Gaps" between the work-sites. Even with all our emerging information and communication technologies,

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[4] Please see supplementary documents for the signed MoU.
[5] http://www.nsf.gov/dir/index.jsp?org=OCI
[6] There are two meanings for P2P. We are not using the Peer-to-Peer meaning in this proposal, but the People-to-People usage common in computer science workflow.

distance and its associated attributes of culture, time zones, geography, and language affect how humans interact with each other (Olson & Olson, 2001a). In addition to the traditionally recognized distance and time gaps, these gaps also include cultural gaps (at the levels of both national as well as organizational culture), governance gaps, regulatory gaps, and infrastructure gaps (Kumar and van Fenema, 2004). Recent management research shows that failures of global projects and collaborations can often be attributed to inadequate awareness of, and inappropriate management of the multiple contexts and their associated gaps inherent in globally distributed work. The failure to understand different demands of collocated and distributed work often results in managers using inappropriate practices and tools for coordinating global projects thereby resulting in frequent coordination breakdowns, frictions, and disappointments. Seldom are these failures of technology or lack of economic resources. Often they are social failures, born out of inappropriate organization and protocol designs.

Thus, consciously managing the consequences of these "Gaps" and the resulting "Polycontextuality" is essential to the success of global collaborations. Polycontextuality occurs in a distributed environment and can be described as the challenge experts face when they attempt to bridge multiple communities or contexts (Engestrom et al., 1995). Therefore, the Global CyberBridges project will develop an integrated socio-technical infrastructure that builds upon the available cyberinfrastructure technologies and the current management research in managing globally distributed work teams and communities.

The proposed Global CyberBridges project complements the existing technical infrastructure with a socio-organizational service-oriented infrastructure that would increase the likelihood of its acceptance and implementation with its target audience – the community of global researchers. It is premised on two considerations: First, the technical Cyberinfrastructure needs to be complemented with analogous socio-organizational infrastructure to increase its level of acceptability and use. Second, its adoption and use has to be simulated by deploying and refining this socio-technical infrastructure in visible global research projects.

C.1.3 Objectives of Global CyberBridges (GCB)

Thus the Global CyberBridges Project has been designed to address the issue of inadequate adoption and use of cyberinfrastructure by first integrating the technical cyberinfrastructure with socio-organizational design concepts and principles for managing globally distributed R&D into a socio-technical design. Second it deploys, refines, and diffuses it through creating pilot prototype communities of globally distributed scientists and users.

Consistent with above, the Global Cyber Bridges (GCB) project has three objectives which directly contribute to the objectives of the NSF CI-Team program, namely preparing the current and future generations of scientists and engineers, as well as minorities, in effectively using the cyber-infrastructure to develop and sustain global collaborative research. While GCB objectives (a) and (b) (below) increase the acceptability and use-ability of CI, GCB objective (c) contributes directly to its diffusion among its target users, thereby preparing them for CI-enabled participation in global research endeavors:

(a) **Development of the Socio-Technical GCB Infrastructure:** cyberinfrastructure for enabling and sustaining research collaborations among networks of globally distributed science and engineering researchers. This socio-technical infrastructure will build upon the technical cyberinfrastructure currently being developed through NSF programs[7]. It will do so by integrating available technology components, training and use-facilitation components, as well as socio-organizational protocols and guidelines for managing globally distributed work, into a generalizable model for implementing ICT-enabled collaboration infrastructures for globally distributed e-science cooperation.

(b) **Prototyping and Refinement:** To implement a prototype community of Information Communication Technology (ICT) enabled, globally distributed science and engineering researchers. Specifically, the proposed GCB project will develop and examine research collaborations between science and engineering

[7] For example please see: PRAGMA http://www.pragma-grid.net/ ; OptIPuter http://www.optiputer.net/ ; International Research Network Connections (IRNC http://www.nsf.gov/pubs/2004/nsf04560/nsf04560.txt); CHEPREO, http://www.chepreo.org/; UltraLight, http://www.ultralight.org/ ; Open Science Grid (OSG), http://www.opensciencegrid.org/. The comprehensive listing can be found at http://www.nsf.gov/crssprgm/ci-team/

researchers from the U.S. and the Peoples Republic of China. The GCB project will build upon and extend the findings of the current collocated CyberBridges project to include the challenges of polycontextuality[8] and global distribution of work. Learnings from this prototype community will be used to test and refine the model proposed in above objective (a). Furthermore, the experiences with the use of the infrastructure will be used as feedback for improving the technical infrastructure.

(c) **Deployment, Monitoring, and Evaluation:** To integrate the researchers, graduate students and faculty from the minority communities in the United States with the Global research community. This objective will build upon both the findings of the CyberBridges project as well as Florida International University's position as a Hispanic serving minority institution. The following figure illustrates the interaction of the international partnerships with relation to these three objectives.

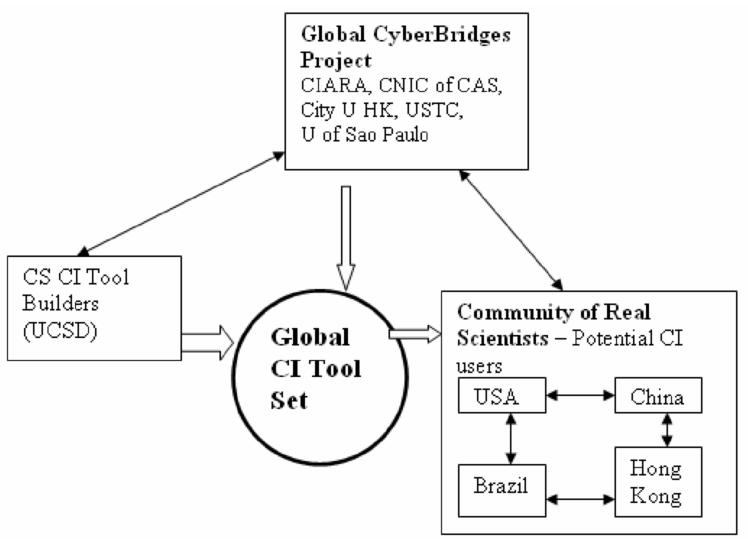

Figure 1 GCB Project Diagram

C.1.4 GCB Activities: Meeting the above objectives

The three objectives outlined in section C.1.3 above require that: (a) The Model of the integrated socio-technical cyber-infrastructure be developed and deployed; (b) Researchers and Scientists be trained in the use of the socio-technical infrastructure; (c) Prototype e-science cross-national collaborations be established to test and refine the prototype model; and (d) The refined and improved model be rolled out and deployed with the target communities of scientists and researchers in the US, China, Hong Kong, and Brazil. Thus we plan a three phased GCB Project:

Phase I: Development of the Socio-Technical GCB Infrastructure: This phase will build upon the experience developed through the current CyberBridges Project and Technical Cyberinfrastructure (SAGE – Scalable Adaptive Graphics Environment[9]) provided by the OptIPuter[10]. Moreover, this model will be extended to include principles, tools and, methods for developing and managing Globally Distributed work (GDW) and Global R&D Projects. The deliverable of this phase will include the establishment of the infrastructure at FIU and a documentation and training ware for the use of the integrated GCB Cyber-infrastructure.

Phase II: Prototyping and Refinement: During Phase II we will initiate cross-national collaborations between scientists and engineers in Florida, China, and Hong Kong. The Integrated GCB Infrastructure will be deployed and tested for efficacy and effectiveness in the field outside of FIU. The currently existing collaborative relationship between University of Science and Technology China (Hefei) and City University of Hong Kong, mediated through PhD students located in Suzhou, will be used to prototype the infrastructure. In keeping with objectives (b) and (c),

[8] Polycontextuality occurs in a distributed environment and can be described as the challenge experts face when they attempt to bridge multiple communities or contexts (Engestrom et al., 1995).
[9] http://www.evl.uic.edu/cavern/sage/
[10] http://www.optiputer.net at the California Institute of Telecommunications and Information Technology

care will be taken to select and include minority students in the projects. During the prototype phase the experiences with the use of the infrastructure will be used to refine the socio-technical model.

Detailed activities in this phase will include establishing cross-national research projects, deployment of the technical and socio-technical infrastructures, training of the scientists and engineers in using the infrastructures, and its continuous monitoring, assessment, and refinement. The focus will be on refining the coordination mechanisms, people-to-people communication protocols, and management methods. This phase will also provide feedback to the designers and builders of the technical infrastructure. The deliverable of this phase will be a deployable prototype and its associated deployment and use processes

Phase III: Deployment, Monitoring, and Evaluation: In the final phase, the refined prototype from the above phases will be rolled out and deployed with a wider set of scientists and engineers from U.S., China, Brazil, Hong Kong. Continuous monitoring and refinement of the GCB cyberinfrastructure will continue in this phase as issues of cross-cultural transfer of ideas and technology reveals new coordination, communication, and management issues. The monitoring phase will also include a multi-stakeholder, multi-criteria, longitudinal evaluation of the project using the Fourth Generation Evaluation Methodology (Guba, 1989).

The final outcome of Phase III and the GCB Project will thus include:

1. A Functioning socio-technical Global Cyber-Infrastructure system
2. Instructions and Training materials for deploying this system, and
3. Established Cross-National and Multi-National Scientific Communities and research projects.

The graduate fellows will work with the CIARA CyberBridges research scientists and the faculty advisors to author a case study package that can be used by other parties to develop and deploy such Global socio-technical infrastructures. This package will contain all of the assessment data, the domain specific challenge and history of the inquiry, and the technologies employed. The case study package will be detailed so that others can use it in the domain of the graduate fellow and faculty member to replicate the inquiry. The case study package will represent examples across the disciplines for applications of CI research[11].

"Best Practices" white papers have been useful conveying to large communities how to employ applications of CI research in video conferencing (Gemmil, et al 2003). The case study packages will be submitted to peer reviewed journals for publication. The full case studies will also be available online. The case studies will be a reference that is technically accessible to the domains that they arrive out of. An inquiry, based in high-energy physics for example, will result in a case study package that is easily understood by other physicists. The case studies will themselves be mechanisms to effectively transfer CI research into the domains, in a widely available and applicable form.

C.2 Research

C.2.a Hypothesis

The CIARA CyberBridges proposes that graduate students engaged in inquiry based learning activities can affect transfer of CI research and that this transfer will increase scientists' rates of discovery and create a CI empowered workforce.

C.2.b Preliminary Research

Before CyberBridges began, we looked at six experiments[12] that lead us to be confident of the hypothesis put forward. One example of this early research is **An experiment with experimental nuclear physics.** A partnership between Dr. Pete Markowitz, graduate students and CI research scientists has allowed for efficient storage and retrieval of "large" data sets. The graduate students use the CI skills and knowledge they have developed as well as

[11] Please see supplementary documents for the case study outline.
[12] See http://cyberbridges.net/description.htm for all six experiment descriptions

their knowledge of experimental nuclear physics to search for relatively infrequent scattering events, such as particular channels in strange quark electro-production. Increases in networking and processing have led them to move data from national laboratories to their own laboratory. The combination of CI research scientist support and traditional faculty mentorship has allowed these students, and the research of the Dr. Markowitz to advance quantifiably. These early research results provided the foundation for the CyberBridges demonstration project.

C.2.c CyberBridges Demonstration Project Research

We include summary findings from the CyberBridges demonstration projects which are at the mid-way point, here to show the potential of building GCB on the success of CyberBridges[13]. These experiments are benefiting from a rich matrix of support infrastructure that was implemented as part of the CyberBridges demonstration project. The implementation of GCB will significantly enhance the scope of impact. The experiments allow us to look at the fundamental issues of graduate student effectiveness, faculty willingness, and usefulness of the research scientists. Furthermore, the rigorous assessment models developed as part of the CyberBridges process are being used for these demonstration project experiments.

First, Unsupervised Pattern Discovery in Protein Structures[14] A collaboration between Computer Science & Bioinformatics and the CyberBridges team. *Pattern Discovery* refers to the task of identifying relevant and significant commonalities or essential differences in related data. In bioinformatics applications, patterns come in different flavors in sequences, structures, shapes, images, and in quantitative and temporal data. Since nature tends to reuse these patterns, pattern discovery is an important task in understanding the nature around us. The aim is to *implement unsupervised pattern discovery tools for protein structure data.* There are two computational tasks. First, a database of proteins and sequence information is searched to look for protein structures that appear to share potentially useful functions. 3-D visualization best reveals these functions. Second, the output database will be searched to locate useful structures.

Second, Modeling Biological Tissue Scaffolds In Three Dimensions[15] A partnership between Biomedical Engineering and CyberBridges CI research scientists. Results of this research will allow for a detailed understanding of the effect of hydrodynamic forces and nutrient mass transfer on the surface of scaffolds (as well as within) that affect the cell growth and further tissue formation. Hence, cyberinfrastructure advantages are invaluable in the applicability of the new and composite simulations first to enrich the knowledge on bioreactor complex fluid flow and second to design more efficient and hydrodynamic scaffolds for enhanced tissue growth understanding. The object is to develop computational models for scaffolds (biodegradable mesh frameworks for tissue growth).

Third, Interplay between Random Matrix Theory and Quantum Field Theory[16] (High Energy Physics data) The goal for physicists is to determine the fundamental parameters that describe each particle in the current standard model and the physics required exceed traditional Quantum Field Theory. Quantum Chromodynamics (QCD) is a theory that has proven to be very accurate in the determination of these parameters. Lattice Quantum Chromodynamics (LQCD), which is a discretized version of QCD, replaces the continuum with a four-dimensional grid for its calculations. LQCD is a challenging computational field that employs large scale numerical calculations, and will be used to verify the current standard model. The aim of this project is working to develop computational capability and precision using random matrix theory. This is a more complete, accurate (as well as more computationally intensive) approach to identify particles in data that will be generated by the CERN Large Hadron Collider (LHC) experiments beginning in 2007. The current task is to organize and divide up the matrices/computational tasks so grad computing can be applied. Results will be compared to the currently well accepted LQCD simulation.

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[13] More complete descriptions are available at www.cyberbridges.net and are discussed in the Preliminary External Assessment Report found in the Supplementary Documents.
[14] Brief description of project from baseline interview. Full interview transcript: http://www.fiu.edu/orgs/ipor/downloads/tmgn.htm
[15] Full interview transcript: http://www.fiu.edu/orgs/ipor/downloads/rgec.htm
[16] Full interview transcript: http://www.fiu.edu/orgs/ipor/downloads/aprsn.htm

Fourth, Functionalities of a specific enzyme for certain reactions[17] Chemistry/Biochemistry and the CyberBridges Co-PIs. Computer simulations of biological macromolecules are widely used in the pharmaceutical industry to accelerate drug discover and in academic research for a host of problems from protein folding to enzyme mechanism. The sizes of the molecular systems and the time scales modeled are memory and compute time intensive. This research is focused on an enzyme, chloroperoxidase1 (CPO) (Sundaramoorthy, 1998), of industrial interest as a potential biological chiral catalyst. The calculations needed are of two types, both of which require substantial computer power: quantum mechanical (QM) calculations for the mechanism work, and molecular mechanical (MM) calculations for the mutation work.

C2.d e-Learning Sciences

GCB will fundamentally use "modeling" in instruction and learning. Mathematical modeling is a form of mathematical problem solving that produces solutions to complex and real, applied problems by creating theoretical representations of the real situation. In complex modeling situations, computer simulations of different ways of representing the mathematics are frequently generated. The inquiries that the GCB fellows construct with their faculty advisors will model these connections. These depictions of the real situation frequently lead to underlying mathematical curve fitting, building of "wind tunnel" representations of the situation of the real problem, or the building of a real, scaled version of the objects of the problem. Technology permits teams of individuals, possibly in different locations and with different skills to enter into the work toward solution of the real problem. It is frequently a systems approach to solve a problem that requires the confluence of varied linked strategies. The Connected Mathematics and Core Plus curriculum projects are based on mathematical modeling as a fundamental teaching/learning strategy and provide two other examples of the potential of the modeling approach in teaching and learning. The COMAP project has demonstrated the effectiveness of modeling in problem solving in high school mathematics. The NCTM "Mathematics as Problem Solving" Standard conceptualizes mathematical modeling using the following diagram (1989, p.138):

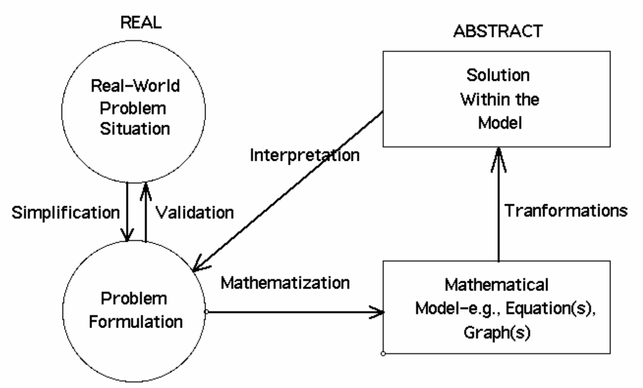

Figure 2 Mathematical Modeling

Research clearly indicates the high potential of the modeling approach for improving learning. Students learn best when the dynamic and developmental process of learning is guided by generalized principles applied to real-world problems or situations. Bruning, Schraw, and Ronning, (1995) highlight key themes relevant to teaching and learning found in cognitive psychology for, including the idea that learning is a *constructive process* and that meaningful learning is *contextual*. Learners are more highly motivated to learn when they can see that what they are learning is useful in their own lives. McCombs (1998) indicates that activities must encourage students to become personally and actively involved in their own learning. The modeling approach provides just such an atmosphere: an atmosphere in which students solve problems, make decisions, work with their peers, and pursue new learning as ideas evolve. We believe that graduate students constructing the models with faculty advisors and IT research scientists will provide the context, and the exploration of the inquiry will be an engaged - personal learning.

[17] Full interview transcript: http://www.fiu.edu/orgs/ipor/downloads/dccd.htm

C.3 Implementation

C.3.a Continuous Cross-Disciplinary Dialogue

The investigators have developed relationships with the CI research community, and are active in working groups that seek to form applications of CI research. The CIARA inquiry-based projects will be example applications of existing or needed CI research. The CIARA CI research scientists will work with existing CI researchers, and NSF program officers to find matches between research interests and CIARA projects. These collaborations will assist CI researchers in understanding needs, and confusions in applying their work.

C.3.b Collaborative Proposal Writing

The early definition of individual CyberBridges projects will come from a one-page proposal document, collaboratively authored by a PhD fellowship candidate and their faculty advisor. The CI research scientists will engage faculty and students at each institute by offering a series of one-hour introductions to the CyberBridges program, including details on how to apply for a fellowship[18]. The fellowship proposal will describe the nature of the domain specific problem and a particular inquiry into the problem that a graduate student can explore applicability of CI. These proposals are not meant to be prescriptive. The use of CI in the inquiry will be hypothetical. The graduate student will research and experiment to determine the veracity of the hypothesis. The one-page document is meant to be a low enough barrier that many faculty members will explore fellowships early in their exploration of topics. These one-page proposals will also be used as a metric for Global CyberBridges implementation success. The number of faculty members that have been engaged enough to author a one-page proposal is a quantitative measurement of CyberBridges staff outreach. Both the ends and the process itself will be instructional, exposing students to the proposal/merit review process.

The average length of the fellowships will be two semesters. Particularly challenging projects may be funded for longer. The faculty advisory board will determine if certain fellowships should be renewed, but it is anticipated that this will not be routine.

C.3.c Faculty review of proposals

The one-page proposals will be brought forward to a faculty committee, chaired by **Co-PI Dr. Chi Zhang**. The committee will evaluate the proposals based on the prospects for CI augmentation, the chance of being replicated and the scholastic suitability of the proposed inquiry. The faculty committees will ensure that the nature of the proposed research can hold up to peer review. The committee will rank the proposals and offer written critiques.

C.3.d Nesting of Graduate Students in Lab

The graduate students will work with the CI research scientists to explore the challenge put forward in the one-page proposal. This exploration will take place in a lab environment, where there are graduate students of various disciplines, all exploring applications of CI research into their domains. This multi-disciplinary environment is a fertile space for cross fertilization of approaches and understandings. Under the tutelage of the CI research scientists the graduate fellows will be engaged in a rich inquiry-based learning experience. The lab facilities and environments at FIU will offer a unique environment for multi-disciplinary exchange.

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[18] Please see http://www.cyberbridges.net/downloads/CyberBridges_Workshop%20Nov21_v5.0.ppt for a sample presentation used to launch the CyberBridges demonstration program.

C.3.e CI Scholastic Certification Program

The CIARA Global CyberBridges fellowship program will have three requirements. One is the inquiry based project that will involve the faculty sponsor. The second is a course of study leading to a certificate in scientific networking and computing. The certification program will require two 3-credit courses. Based on the existing lectures developed in the pilot CyberBridges program, we will develop a new graduate-level Grid Computing course. The course will include lectures, seminars, and a course project. The lectures will cover topics such as High-Speed Networks, Design and Implementation of Clusters, Globus Toolkits, Virtual Data Systems, Resource Scheduling, MPI, Web Services, Grid Services, and Job Workflow Processes. The course project will require students to "gridify" a scientific application. Students will conduct experiments on the CyberBridges cluster, and leverage extramural resources, such as TeraGrid and Open Science Grid as requirements might justify. The courses will be added into the graduate course catalog of Computer Science, thereby institutionalizing CyberBridges at FIU.

After the basic Grid Computing course, the students will further take an independent-study course to conduct interdisciplinary research. The course will provide a solid foundation of understanding about how CI research takes place (Gelès, 2000), and how to be involved in the applications of it. While many faculty members today are not aware of NSF programs that have historically funded research and infrastructure programs, the graduate fellows in their careers as faculty members will have a rich understanding of the CI community. Permanent Equipment for the certification program includes both high-performance networking and grid computing training components. The equipment purchased for the CyberBridges demonstration program (2005-2006) will be reused for the CyberBridges implementation program. The following diagram provides details as to what is available and how it is set up.

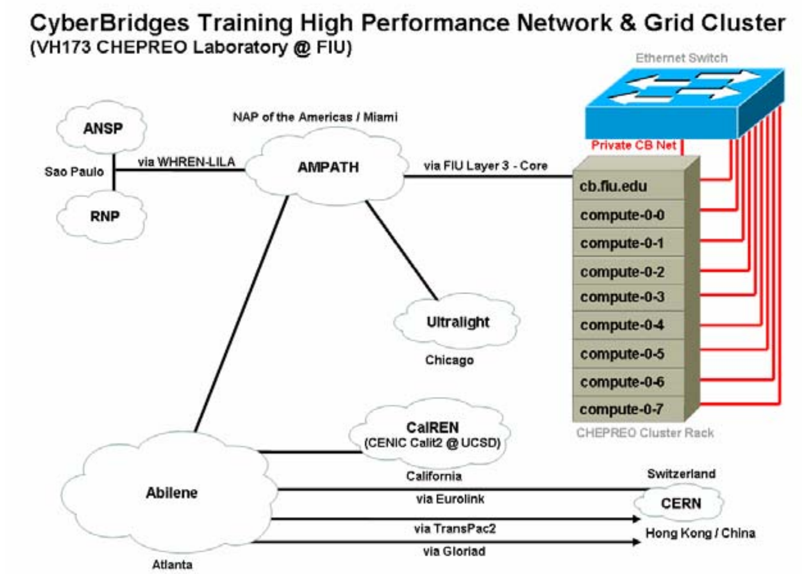

Figure 3 CyberBridges Laboratory Equipment

The CyberBridges certification program is supported by Co-PIs Zhang and Sadjadi. Zhang has incorporated Grid Computing into a graduate course at FIU. The course included 8 hours of lectures on Grid, and a mini-project on grid computing. This program is an important tool for institutions apart from FIU to directly benefit from CIARA's CyberBridges initiative. As the graduate fellows interview for post-doctoral positions, outside programs will be able to determine if such expertise could be beneficial for their departments. This exponentially increases the scope of impact of CIARA[19]. The combination of an inquiry-based learning program and the certification program will best prepare the next generation of scientists, engineers and educators to use and understand IT research.

The CyberBridges pilot project has engaged the heterogeneous faculty of FIU, whereas GCB will expand this model across distance and international boundaries. This engagement will consist of an open dialogue facilitated by the

[19] Please see attached letter of support from Tom Milledge

faculty investigators, with the full support of university administrators. This dialogue will foster CyberBridges fellowship proposals and projects from any discipline on campus ranging from the physical sciences to the humanities. Each project will be faculty led, and taken on as a result of the dialogue with CI research scientists.

C.4 Community Engagement and Participation

C.4.a Continuous Dialogue

The CIARA GCB presentations to faculty department meetings and the brown bag lunches will foster an environment of continuous dialogue. We will work collaboratively with our international partners to stage parallel outreach activities at all sites. The FIU faculty communities will be engaged creatively to understand applications of CI research. This environment will be a fertile space for multi-disciplinary research to be initiated. The open exchange will be a model for institutions that replicate the CIARA CyberBridges.

C.4.b Student outreach

The graduate fellows will present their work with CI research to their peers. The graduate fellows will work with their peers to present the role of CI research to undergraduate classes. Having graduate students that are knowledgeable about a topic, acting as role models for undergraduate students, has proven to be effective in minority serving institutions (Stearns and Snyder 2002). Through the outreach work of the CIARA fellows, a large community will be engaged in reaching out to the student community. In disciplines that have not effectively appealed to minorities, we believe that CI research may offer a new perspective as to the excitement in those fields. By having role models convey their enthusiasm in using CI research in the humanities or physical sciences, the opportunity for impact is significant (IBID 2002).

C.4.c Culture changing nature of work

The CIARA CyberBridges is asking faculty members to look at CI in a new way. To see it not as simply a tool that is used in a predetermined manner, but as a domain of research itself. The goal is to change the culture of the faculty into one that sees working with technology as collaboration, rather than simply an application. The difference is profound. The systemic nature of CI results in non-iterative change, which confounds faculty who are used to the iterative pace of discovery in other disciplines. This recognition of the dynamic of CI research and the desire to collaborate will affect the culture. The notion of infrastructure being a barrier to participation will no longer have a death grip on the creativity of the faculty. This shift will result in scientists, engineers, and educators who are fully integrating CI into their professions.

C.5 Project and Management Plans

C.5.a Project Structure

CIARA will be responsible for the outreach programs (department meeting presentations, brown bag lunches, fellows undergraduate lectures, and conferences), soliciting fellowship proposals, administering the graduate certification program, and providing the IT tools and expertise for the structured inquiry projects.

C.5.b Calit2 Technology Transfer Sub-Contract

We propose a sub-contract to the California Institute for Telecommunications and Information Technology (Calit2) located on the University of California at San Diego (UCSD) campus to insure that the leading edge collaborative technologies are utilized by the CyberBridges fellows. Dr. Peter Arzberger of Calit2 and PI of PRAGMA will lead the technology transfer proposed. Larry Smarr, director of Calit2 and PI for the NSF funded OptIPuter project said, "OptIPuter is prototyping a 21st-century cyberinfrastructure, based on optical networking, to support data-intensive scientific research and collaboration. This infrastructure will enable scientists to collaborate with remote colleagues and large-scale data sets in real time over high-performance networks." This sub-contract to implement products of the OptIPuter project, including 4K High Definition people-to-people and people-to-application hardware and software will be installed in each CyberBridges laboratory.

There are three goals we have for the use of technology in the Global CyberBridges Project. First, we want to have technology for distance teaching. Second, we will want to have a technology that will allow distance collaboration. Third, we are looking for technology to help visualize complex phenomena. We have decided to use tile display walls, both because of the costs (using off the shelf equipment) and because of the ability to scale the systems if needed.

The Global CyberBridges (GCB) Project will leverage the advances and developments of the NSF funded OptIPuter project (www.optiputer.net). The OptIPuter, so named for its use of Optical networking, Internet Protocol, computer storage, processing and visualization technologies, is an envisioned infrastructure that will tightly couple computational resources over parallel optical networks using the IP communication mechanism. The OptIPuter exploits a new world in which the central architectural element is optical networking, not computers - creating "supernetworks". This paradigm shift requires large-scale applications-driven, system experiments and a broad multidisciplinary team to understand and develop innovative solutions for a "LambdaGrid" world. The goal of this new architecture is to enable scientists who are generating terabytes and petabytes of data to interactively visualize, analyze, and correlate their data from multiple storage sites connected to optical networks.

The OptIPuter has developed tools, and in addition has leveraged tools of the Electronic Visualization Lab (EVL, http://www.evl.uic.edu/index2.php) at the University of Illinois Chicago. Out of this activity come a variety of software that we will use (in some cases be early users) for GCB. One package is SAGE, Scalable Adaptive Graphics Environment (http://www.evl.uic.edu/cavern/sage/), which provides an architecture for managing multiple graphics applications to local and remote tiled displays. For example, in the SAGE desktop, there can be streaming HDTV windows providing a view of the scientists and their work environment, streaming instruments or sensor data, high-resolution datasets, and laptop displays. These windows can be resized or repositioned dynamically across the tiled display to support research. Multiple high-resolution applications can be run on the same tiled display, with each different application being executed and controlled by a different computer. Currently, SAGE is available via the Web, and is also distributed under the Rocks cluster software distribution.

This project will provide a two-way bridge between the OptIPuter project and its tools and a set of users. The funding for this component will assure the transfer of technology as soon as it is available, working with the students and investigators to ensure the technology is working, and feedback on how the products work. SAGE is ready to be used by the project. As other components of the tools are ready, they will be deployed in this project.

C.5.c Fellowship RFP Solicitation & Review

The CyberBridges advisory committee will consist of three faculty members that will represent a broad range of domains. The committee will have senior and junior faculty members. The committee will annually work with the outside consultants to ensure the IT research being proposed by the CIARA research scientists is applicable and current. They will also serve as the faculty board members to review the fellowship RFP responses for FIU's component of GCB. Our partner institutions will develop and follow a similar process to be consistent and complimentary to each institutions' cultural norms. The project is structured so that each graduate fellow will have a faculty advisor (typically their thesis advisor) and one research scientist advisor.

The implementation project will offer up to eight two-semester long fellowships at each participating institution. Each fellowship will start with a normative analysis, then an inquiry project, followed with a case study package. In addition, each fellow will be required to successfully complete the certification program. Failure to complete the terms of the fellowship will result in a suspension of the fellowship. While the inquiry-based project does not have to meet any prerequisite of success, it will be judged on its thoroughness.

C.5.d Management Structure

The PI, Heidi Alvarez will direct the activities in CIARA for CyberBridges. In the center role, she will convene the faculty review panel, chaired by Co-PI Chi Zhang. She will manage the research scientists associated with GCB, annually report the activities of the center to the faculty advisory board, oversee fellowship disbursements, and manage the external review process. The review panel will consist of faculty members nominated by the chairs, and approved by the FIU Vice President for Research. Co-PI Kuldeep Kumar will hold primary responsibility for the international coordination and collaboration proposed through Global CyberBridges. Co-PI Ibarra, in synergy with his role as PI of the International Research Network Connections (IRNC) award from NSF-OCI for the Western Hemisphere Research and Education Network-Links Interconnecting Latin America (WHRE/LILA) project, will be the primary contact with our Brazilian collaborators. Finally, Co-PI Sadjadi will lead the team teaching of the CyberBridges curriculum for the FIU and international students participating in the program.

C.5.e Schedule and Milestones: Activities & Dissemination Plan

Given the complexities of coordinating an international schedule, the schedule and milestone presented herein reflects the FIU calendar as it is now known. Adjustments will be applied to coordinate intense collaborative activities with the international partners. While we do not expect the global cohort to be able to participate in each lab based syllabus activity, there will be frequent scheduled distributed collaborative learning community activities. By using the advanced collaborative technologies supplied by Calit2, each globally distributed CyberBridges laboratory will also offer ongoing casual opportunities for collaborative learning and research activities.

Additionally, the CyberBridges yearly cycle actually takes 15 months in order to achieve important research dissemination project goals for the coordination of conference presentation and publication. We will begin the Year 2 and Year 3 fellowship solicitation cycles while the previous year's student fellows are presenting their results and the external assessment committee works with the Co-PIs, student and faculty advisors to complete the annual reports. Because yearly funding is triggered by submission and acceptance of annual reports, we propose to submit annual reports at the beginning of October for each year of the project and then amend these reports with year end results. This will allow us to maintain continuity of the funded activities.

Furthermore, the fellows are required to participate in two undergraduate lectures on CI research in the domain, and one case study conference as part of the dissemination activities. The operational milestones of GCB come from the execution of the fellowship activities, and the annual assessment of the delta from the past normative states. After the three years of the project, the external assessment report will be authored examining broader impacts. All dissemination material will be available on the web site.

Table 1 GCB Schedule and Milestones Table

Year 1 (October 2, 2006 – December, 2007)		
October 2, 2006	Project starts	Several brown bag lunches commence for project dissemination to reach faculty and students in targeted departments
October 15th, 2006	International project participants meet at PRAGMA in Osaka for Kick-Off meeting	
November 1st, 2006	Solicitation for fellowship posted	
December 4th, 2006	Faculty committee selects four fellowships	
January 8th, 2007	CIARA fellowship program begins with course on High Performance Grid Computing and Networking	
May, 2007	Case study research activities intensify	
August, 2007	Case studies published Preparations for presentation at appropriate conference	CyberBridges website (e.g. SuperComputing, PRAGMA, ACM, IEEE)
Fall, 2007	Case studies presented at conference and published	
October, 2007	NSF Annual Report Submitted	This triggers Year 2 Funding
December, 2007	NSF Annual Report Updated in FastLane to	

	include External Assessment Report	

Year 2 (October 1, 2007 – December, 2008)		
October 1, 2007	GCB Year 2 project start	Project dissemination to reach faculty and students in targeted departments
October, 2007	International project participants meet at PRAGMA for Year 2 Kick-Off meeting	
November 1st, 2007	Solicitation for fellowship posted	
December 3rd, 2007	Faculty committee selects four fellowships	
January 7th, 2008	CIARA fellowship program begins with course on High Performance Grid Computing and Networking	
May, 2008	Case study research activities intensify	
August, 2008	Case studies published Preparations for presentation at appropriate conference	CyberBridges website (e.g. SuperComputing, PRAGMA, ACM, IEEE)
Fall, 2008	Case studies presented at conference and published	
October, 2008	NSF Annual Report Submitted	This triggers Year 3 funding
December, 2008	NSF Annual Report Updated in FastLane to include External Assessment Report	

Year 3 (October 1, 2008 – December, 2009)		
October 1, 2008	Year 3 of GCB starts	Project dissemination to reach faculty and students in targeted departments
October, 2008	International project participants meet at PRAGMA for Year 3 Kick-Off meeting	
November 1st, 2008	Solicitation for fellowship posted	
December 3rd, 2008	Faculty committee selects four fellowships	
January 7th, 2009	CIARA fellowship program begins with course on High Performance Grid Computing and Networking	
May, 2009	Case study research activities intensify	
August, 2009	Case studies published Preparations for presentation at appropriate conference	CyberBridges website (e.g. SuperComputing, PRAGMA, ACM, IEEE)
Fall, 2009	Case studies presented at conference and published	
December, 2009	NSF Final Report Updated in FastLane to include External Assessment Report	

In addition to the above named schedule and milestones we anticipate that there will be several yearly international collaborative activities under the auspices of the PRAGMA organization (bi-yearly); the WHREN-LILA project in Latin America and the Caribbean (bi-yearly); the Chinese American Networking Symposium (CANS; Yearly), and the Hispanic American Universities and Colleges (HACU; Yearly) meetings. These meetings and locations have been carefully chosen for easiest accessibility by GCB participants without the added overhead of developing a new set of logistics specific to GCB. While it would be ideal to move all students, faculty and CI research scientists associated with GCB, that is not a financial or logistical possibility. As such, we will provide travel funding as available to serve the socio-technical objectives discussed in section C.1.1, sometimes for international collaborative leads for planning purposes, sometimes for students for collaborative research presentations and cultural exchange.

C.5.f Evaluation Plan – Assessment of GCB

Measuring GCB sub-project successes will fall under a number of rubrics. When a project is begun with a faculty member, a graduate student, and a CI research scientist, the first course of action will be to document the normative state. As the metrics for progress vary significantly by domain, this will be a highly customized activity, but fundamental to the operation of CIARA's Global CyberBridges implementation. Different faculty members may choose to judge their progress in different ways even inside of domains. GCB will document this, and then use it as a baseline. The success of GCB implementation will then be an assessment of the defined metrics. We will create a list of CI technologies and methodologies (broken down in categories similar to those in C.1), but more customized to compliment the existing CyberBridges assessment rubric[20]. Each project will select which specific areas it is utilizing. However, we still also require metrics to assess how projects utilize these areas. While there will be early indicators of GCB's success, the nature of the change proposed will take longer to accurately assess.

The assessment of the scholastic and technological competency of GCB will be assessed by an External Review Committee. The external review committee will be contracted to measure the pedagogy against known best practices, and the technology against the current work of the CI research community, as well as auditing the operations of the GCB implementation. The External Review Committee will perform a Baseline Study at the start of each year of Global CyberBridges, and provide an assessment as described above to be included in the GCB Annual Report to the NSF. A preliminary report of the CyberBridges pilot is attached in the supplementary documents.

C.5.g Sustaining the Project beyond the Funded Period

The long-term vitality of the CIARA is dependent on the success of the CyberBridges graduate fellows. The assessment rubrics are in place to demonstrate a return on investment to the various disciplines. The CIARA is not proposing a budget for infrastructure beyond training and collaboration hardware and software for the CyberBridges laboratory at FIU - that is a responsibility of projects and the institutions. CIARA is implementing a system for using graduate fellowships to increase the rate of discovery and improve the CI skill set of faculty and students. The research scientists are an essential part of the CIARA system. The faculty participants will determine the longevity of CIARA. If the faculty sees a significant return on investment, they will secure support for the fellowships and the research scientists. There are clear and direct funding mechanisms to ensure that CIARA operates beyond the length of NSF support. The same factors would lead to other institutions adopting the CIARA model. Both of these outcomes depend on CIARA's success.

CIARA is poised to succeed. The investment is directed primarily to graduate fellowships. They are the next generation of scientists, engineers and educators who will be nurtured in their explorations of IT. The methodology for fostering, inquiry based learning is sound (Bransford, Brown, & Cocking, 1999), the IT research is compelling (Joy, Kennedy et al. 1999), the need is significant across the disciplines (Atkins, et al 2003), so CIARA has a mandate and a means to effect long-lasting change.

C.6 Broader Impacts of the Proposed Activity

The smallest impact of CIARA's CyberBridges will be a change in the way that the largest Hispanic minority-serving institution in the continental U.S. views cyberinfrastructure. The CIARA project represents an inclusion in the CI research community of benefits. Where CI has raised the tide, not all vessels have been lifted. CIARA will bring the benefits to domains and groups that have yet to realize the fantastic impact. Over the pilot year, CIARA will include underrepresented groups supported in areas of national importance. CyberBridges will impact the faculty doing research and teaching today, and the faculty of the future. This impact alone is significant to the U.S. society.

The CIARA model will likely have a much larger impact. Institutions across the country support CI by investing in systems specialists and IT support staff. The application of CI is limited to the vision of institutional information

[20] Please see CyberBridges Preliminary Assessment Report in the supplementary documents section.

technology plans. There is a great divide between these plans, and the needs of the faculty. A successful CIARA, shown through the emphasis on assessment, will profoundly affect the national models for CI. When institutions can affect more efficient CI transfer by investing closer, in graduate students, rather than farther, in systems analysts, to institutional missions, a substantial impact will occur. The re-focusing on institutional expenditures from tangential technology support functions, to synchronous fellowships will have profound impact on the effectiveness of our inquiries today, and the creativity and effectiveness of diverse generations to come.

C.6.a The Partnership in Academic Communities (PAC) in Excellence

Our research at FIU during the past nine years with grades 7-12 "at-risk" students of an urban public school district clearly indicate the strong potential that instructional technology used in mathematics and science contexts has in improving the academic success rates of this population. Recent national reports have indicated a continuing major problem of student drop out, which particularly impacts underrepresented, minorities (National Center for Educational Statistics, 1999; Kaufman, Klein, & Frase, 1999). Schools often fail to address the special circumstances including community, economic, family, ethnic, and racial status that characterize students at risk to drop out (Natriello, McDill, & Pallas, 1990).

GCB will serve a similar profile of graduate students. This work will be leveraged to allow us to design a nurturing environment for the CyberBridges graduate students, and a scholastic program tailored to these demographics' needs. The PAC program conclusions design and operational elements of GCB are:

1. PAC program students are more able to work together collaboratively and systematically.
2. PAC program students are often more willing to take risks, to experiment and try out possibilities.
3. PAC program students tend to be more persistent in their pursuit, when the interest or challenge is there to make it worthwhile.

Co-PI Sadjadi will be the designated manager for this component of the activity. He will base development on improvement with respect to the quality of education measured in terms of efficiency of instruction, effectiveness of pedagogical techniques, and the quality of testing and assessment.

C.7 Results from Prior NSF Support

C.7.a CyberBridges

Heidi Alvarez, PI, Julio Ibarra, and Chi Zhang, Co-PIs: CI-TEAM demonstration project OCI # 0537464. Program details at www.cyberbrides.net. Preliminary results from the External Assessment Committee Report are provided in this proposal's supplementary documents.

C.7.b WHREN-LILA

Julio Ibarra, PI & Heidi Alvarez, Co-PI. OCI-IRNC: WHREN (Western Hemisphere Research and Education Networks): Increasing the Rate of Discovery and Enhancing Education across the Americas PI Award #0441095 was made as a Co-operative agreement on January 1, 2005. Throughout the Americas, geographically distributed researchers, students, and instruments need a seamless cyberinfrastructure to inquire and discover collaboratively. WHREN addresses the existing and future needs for improved North American (especially U.S.)–South American connectivity and LILA (Links Inter-connecting Latin America) specifically focuses on the need for connectivity through new links. Monthly newsletters and 2005 annual report available at http://www.whren-lila.net/ .

C.7.c AMPATH

Julio Ibarra, PI & Heidi Alvarez, Co-PI: (ANI-0123388): AMPATH Workshop to Identify Areas of Scientific Collaboration between the U.S. and the AMPATH Service Area, April 15-17, 2001 (ANI-0220176): First AMPATH International Conference, Valdivia, Chile, April 12, 2002 (ANI-0215434) AMPATH StarLight Rio Grid Workshop, held February 7-8, 2002. Newman and Alvarez worked with RNP Brazil to test COJAC application for HEP visualization. STI - AMPATH Collaborative Research and Education Operational and Functional Support, Co-PI for AMPATH (ANI-0231844) funded September 12, 2002, ongoing. Co-PI for (ANI-6188654) AMPATH Workshop, Miami, January, 2003: Fostering Collaboration and Next Generation Infrastructure. Results are available now at www.ampath.fiu.edu .

C.7.d CHEPREO

Heidi Alvarez, Co-PI: An Inter-Regional Grid-Enabled Center for High Energy Physics Research and Educational Outreach at FIU (CHEPREO) Co-PI Award #0312038 was made on 09/29/03 and annual reports for 2004 & 2005 are available on www.chepreo.org. Alvarez and Sr. Personnel Ibarra are responsible for the development and support of cyberinfrastructure for CHEPREO as well as the administrative lead of this complex collaboration funded by multiple directorates and offices of the NSF. Florida International University (FIU), together with partners at FSU, UF, and Caltech. The CHEPREO team continues to make outstanding contributions in the development of the CMS experiment at CERN while equally engaged in educational outreach efforts.

C.7.e Pan-American Advanced Studies Institute (PASI) program

PI Ibarra & Co-PI Alvarez: Pan American Advanced Studies Institute in Mendoza, Argentina May 2005; Grid Computing and Advanced Networking Technologies for e-Science PI Awarded # 0418366, OISE | Americas Program funded August, 2004. Program and curriculum are available at www.ciara.fiu.edu/pasi.

References

Atkins et al. (2003) Revolutionizing science and Engineering through Cyberinfrastructure: report of the National Science Foundation Blue-Ribbon Panel on Cyberinfrastructure. Arlington, Va. The National Science Foundation

Boyer Commission on Educating Undergraduates in the Research University (1998). *Reinventing undergraduate education: A blueprint for America's research universities*. Menlo Park, CA: Carnegie Foundation for the Advancement of Teaching.

Bansford, John, Ann L. Brown, and Rodney Cocking (Eds.) (1999). How People Learn: Brain, Mind, Experience, and School. Washington DC: National Academy Press.

Bruning, R., Schraw, G., & running, R. (1998) *Cognitive Psychology and Instruction*. New York, New York. Prentice Hall

Cambre M.A. (1991) The state of the art of instructional television. (pp. 267-275), In G.J. Anglin (ed) *Instructional Technology, Past, Present and Future*. Englewood Cliffs: Prentice-Hall.

COSMOlogic GmbH & Co. HG. Turbomole 5.6. Burscheider Str. 515 D-51381 Leverkusen. Germany.

Dumas, Marlon, Wil M. P. van der Aalst, and Arthur H.M. ter Hofstede, "Process-Aware Information Systems: Bridging People and Software through Process Technology, Wiley-Interscience, 2005 p. 14.

Engestrom, Y., Engestrom, R., & Karkkainen, M. (1995). *Polycontextuality and boundary crossing in expert cognition: Learning and problem solving in complex work activities.* (Vol. 5).

Foster, Ian. "Service-Oriented Science." Viewpoint. Science 6 May 2005: Vol. 308. no. 5723, pp. 814 – 817; DOI: 10.1126/science.1110411. http://www.sciencemag.org/cgi/content/abstract/308/5723/814

Frase, M., Kaufman, P., & Klein, S. (1999, April). Dropout rates in the United States: 1997. Washington, DC: National Center for Education Statistics. NCES 1999-082.

Geles, C., Lindecker, G., Month, M., & Roche, C. (2000). *Managing Science; Management for R&D Laboratories*. A Wiley-Interscience Publication. John Wiley & Sons, Inc.

Gemmil & etc. (2003) The Videoconferencing CookBook. Birminghan, Alabama.

Guba, E. G. & Lincoln, Y. (1989). *Fourth generation evaluation.* Newbury Park, California. London, England. New Delhi, India: Sage Publications.

Hazemi, R., Hailes, S., & Wilbur, S. (1998). *The Digital University: Reinventing the Academy*. Berlin: Springer-Verlag.

Joy, Bill, Kennedy, Ken & etc. (1999) *The Presidents Information technology Advisory Board: Report to the President*. Washington, D.C. National Coordination Office

Kaufman, P., Klein, S., & Frase, M. (1999). Dropout Rates in the United States, 1997. Statistical Analysis Report. U.S. Department of Education.

Kumar, K., and P.C. van Fenema. 2004. Passing the Baton cross the Divide: Distance, Interdependence, and Coordination in Global Software Development. FSO (Financial Services Outsourcing) Magazine, http://www.fsoutsourcing.com 1 (2).

Lee, Hong-In, Dexter, Annette F., Fann, Yang –Cheng, Lakner, Frederick J., Hager, Lowell P., & Brian M. Hoffman. J. Am. Chem. Soc. 1997, 119, 4059-4069

Mcombs, B. & Whisler, J. (1998) *The Learner-Centered Classroom and School: Strategies for increasing Student Motivation and Achievement.* Jossey-Bass.

McKinley, P.K., Sadjadi, S. M., Kasten, E. P., & Cheng, B. H.C. Composing adaptive software. IEEE Computer, pages 56-64, July 2004.

Mumford, E. "Socio-Technical Design: An Unfulfilled Promise or a Future Opportunity," in R. Baskerville, J. Stage, and J.I. DeGross (Eds.), *Organizational and Social Perspectives on Information Technology*, Boston: Kluwer Academic Publishers, 2000, pp. 33-46.

NAEP 1996 Mathematics Report Card for the Nation and the States: Findings from the National Assessment of Educational Progress. Washington, DC: National Center for Education Statistics.

National Council of Teachers of Mathematics (NCTM, 1989). Curriculum and evaluation standards for school mathematics. Reston, Va.: NCTM

Natriello, G., McDill, E. L., & Pallas, A. M. (1990). *Schooling disadvantaged children: Racing against catastrophe*. New York: Teachers College Press.

Olson, G. M., & Olson, J. S. (2001a). Distance matters, science of collaboratories. Human Computer Interaction, 15, 139-179. Retrieved from http://www.scienceofcollaboratories.org/WorkshopStuff/June2001/pdfs/Olson_Olson_distance_matter.pdf.

Olson, G. M., Malone, T. W., & Smith, J. B. (2001b). Coordination Theory and Collaborative Technology: Lawrence Erlbaum Associates.

Pournelle J. (1994) *An Educational Trip*. *Byte*, 197-210.

Reese, C. M., Miller. K. E., Mazzeo, J, & Dossey, J. A. (1997, February).

Sadjadi, S. M., McKinley, P. K. Autonomic Computing: Concepts, Infrastructure, and Applications, chapter Transparent Autonomization in Composite Systems. Taylor and Francis Books, 6000 Broken Sound Parkway, NW, Boca Raton, FL 33487, 2006. To appear.

Sadjadi, S. M., McKinley, P. K., & Cheng, B. H.C. Transparent shaping of existing software to support pervasive and autonomic computing. In Proceedings of the first Workshop on the Design and Evolution of Autonomic Application Software 2005 (DEAS'05), in conjunction with ICSE 2005, St. Louis, Missouri, May 2005.

Sundaramoorthy, M., Terner J., & Poulos, TL. Chemistry & Biology. Vol. 5, 1998, 461-73.

Stearns, C. & Snyder, T. (2002) *Hispanic Serving Institutions Statistical Trends form 1990 to 1999*. National Center for Educational Statistics. Washington, D.C.