Western-Hemisphere Research & Education Networks Links Interconnecting Latin America (WHREN-LILA)

International Research Network Connections (IRNC) Program Review October 24-25, 2006

Julio Ibarra, FIU Heidi Alvarez, FIU Chip Cox, FIU-ANSP John Silvester, USC-CENIC





Outline

- History and Background
- Overview of the WHREN-LILA project
- Proposed objectives of the award
- Year 1 milestones
- Current Year 2 status and future plans
- Communities and Applications



History and Background

- Network connectivity to Latin America pre-IRNC
- Regional Development
- Rationale for WHREN-LILA



Network connectivity to Latin America pre-IRNC

- Argentina, Brazil (national and the State of Sao Paulo), Chile, Panama and Venezuela connections through Miami
- Mexico connections through San Diego and El Paso
- Peerings with Internet2 and other US R&E networks through AMPATH, CaIREN and UTEP
- International and FedNet peerings at STARTAP/Starlight from Miami provided by AMPATH





Regional Development

- The ALICE project funded an IP research network infrastructure within the Latin American region and towards Europe
- Managed by DANTE, 80% funded by European Commission
- 4 European and 19 Latin American partners
- Directed CLARA organization and RedCLARA backbone

Argentina (RETINA)	Ecuador (CEDIA)	Panama (REDCYT)
Brazil (RNP)	El Salvador	Paraguay (ARANDU)
Chile (REUNA)	(RAICES)	Peru (RAAP)
Costa Rica (CRNET)	Guatemala (RAGIE)	Uruguay (RAU)
	Mexico (CUDI)	Venezuela
	Nicaragua (RENIE)	(REACCIUN)

(NRENs in formation indicated in RED)



CLARA network topology

Network Characteristics:

- 155 Mbps backbone ring
- 622 Mbps connection to Europe
- local traffic remains within the region
- 10 to 45 Mbps spur links
- 4Mbps satellite link to Cuba
- Network to be operated by CLARA (through CUDI and RNP)





Rationale for WHREN-LILA

- RedCLARA established an important regional infrastructure
- Inter-regional connectivity to North America not on par with Europe
- Significant U.S.-Latin American collaborations were underserved to support network-enabled science and engineering research
- NSF investments for network resources were primarily for Europe and Asia
- These regions have significant resources for science: telescopes in South America, tropical rain forests in Central America



Overview of the WHREN-LILA project

- WHREN-LILA Proposal Concept
- WHREN-LILA Funded plan
- Project Governance



WHREN-LILA IRNC Award 0441095

- 5-year NSF Cooperative Agreement
 - Florida International University (IRNC awardee)
 - Corporation for Education Network Initiatives in California (CENIC)
 - Project support from the Academic Network of Sao Paulo (award #2003/13708-0)
 - CLARA, Latin America
 - CUDI, Mexico
 - RNP, Brazil
 - REUNA, Chile
- Links Interconnecting Latin America (LILA) aims to Improve connectivity in the Americas through the establishment of new inter-regional links
- Western-Hemisphere Research and Education Networks (WHREN) serves as a coordinating body whose aim is to leverage participants' network resources to foster collaborative research and advance education throughout the Western Hemisphere













WHREN-LILA proposal concept

- (3) 2.5Gbps links + dark fiber segment
- U.S. landings in Miami and San Diego
- Latin America landings in Sao Paulo, Santiago and Tijuana
- \$8.6M over 5 years





WHREN-LILA Funded Plan

- (1) 1.2Gbps link
 evolving to 2.5Gbps +
 dark fiber segment
- U.S. landings in Miami and San Diego
- Latin America landing in Sao Paulo and Tijuana
- \$5M over 5 years





LILA East Design: AMPATH International Exchange Point





LILA West design

Physical Diagram

Links Interconnecting Latin America

Logical Diagram



Project Governance

- Steering Committee
- Engineering Committee
- Research Advisory Committee



Steering Committee

Luis Lopez John Silvester **Jim Dolgonas Florencio Utreras Michael Stanton Carlos Casasus** Julio Ibarra Chip Cox Heidi Alvarez **Nelson Simoes** Paola Arellano

ANSP **USC-CENIC** CENIC CLARA CLARA CUDI FIU **FIU-ANSP** FIU RNP REUNA



Engineering Committee

Jorge Marcos Jorge Yamamoto **Dave Reese** Chris Costa Eriko Porto Fernando Muro Hans Reyes **Ernesto Rubi** Xun Su Alexandre Grojsgold Sandra Jaque

ANSP ANSP CENIC CENIC **CLARA** CUDI CUDI FIU Caltech/CHEPREO RNP REUNA



Research Advisory Committee

Paul Avery Jim Kennedy Sergio Novaes Alberto Santoro Alan Whitney Chris Smith Harvey Newman Jim Beach Paul Mantsch HEP Optical Astronomy HEP HEP Radio Astronomy Optical Astronomy HEP Biodiversity Cosmic Ray astrophysics



Proposed Objectives of the Award

- Improve U.S. South American network connectivity
- Bridge regional network infrastructures with existing and emerging optical exchanges in the North and South
- Form a network collaborative that complements the Western Hemisphere's evolving regional networking activities
- Promote efficient peering through a distributed exchange model
- Enable communities of scientists to expand their research activities, teaching, and learning
- Evolve connections to 2.5 Gbps, as resources and economies permit



Significance of Proposed Objectives

- Brings Latin American researchers further into the research community as peers with North America, Europe and Asia research communities
 - Central and South American region is underserved compared to NSF investments of network resources for Asia and Europe regions
- Establishes a high-performance link into Sao Paulo, scientific capital of the country and region
- Bridges Spanish speakers of the Western Hemisphere, benefiting U.S. Hispanic students, researchers, and teachers
 - PRAGMA, Cyber Bridges, HACU and other programs leverage infrastructure



Year 1 Milestones

- Project Coordination
- LILA Implementation
- Dissemination and Outreach



Year 1 Milestones Project Coordination

Governance Structure

- Jan 05: Established Steering Committee for project management and coordination
- Jan 05: Established Engineering Committee
- Jan 05: Established Research Advisory Committee
- Project meetings
 - Apr 05: LILA Kickoff meeting in Veracruz, MX, and to discuss project operational requirements



LILA Kickoff Meeting







WHREN-LILA KICKOFF MEETING VERACRUZ, MEXICO, MAY 1, 2005

🔆 NSF SCI: IRNC 0441095



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Interconnection and Peering Plan





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 - Aug 05: Engineering Committee meeting for interconnection and peering plan in Sao Paulo. Resulted in design (diagram) and action plan
 - Sep 1: WHREN initial meeting held at iGrid 05. Meeting focused on the following four areas:
 - Western Hemisphere Conference: applications focused, uniting researchers across the Western Hemisphere
 - Web Forum for communication involving the RENs in the Western Hemisphere
 - WHREN Fellowships: Funding graduate students across the continent to support advancing research with the network resources



- Jan 05: Revised 5-year plan for reduced budget
- Jan 05: NSF CHEPREO funds active equipment for LILA East exchange points
- Jan 05: Renegotiated contracts with Latin American Nautilus for capacity lease and with Global Crossing for dark fiber between San Diego and Tijuana
- Feb 05: Formalized Sao Paulo exchange point design with Latin American partners



- Apr 05: Customs returned Cisco equipment labeled "made in China". Delayed LILA West connection by 3 Months
- Apr 05: Cisco ONS equipment shipped to Sao Paulo, then held in Customs
- May 05: Negotiated contract with Bestel for Tijuana cross connect. Priced at \$6,400 MRC



- Jun 05: Brazilian router manufacturer files complaint to have equipment released from Customs. Cisco ONS remains in Customs
- Jul 05: Tijuana x-connect renegotiated down to \$2K/month
- Jul 05: Connected CUDI and CLARA at LILA West over single GigE
- Jul 05: Established peering with Abilene using GRE tunnel over CalREN
- Sep 05: Received pricing from DANTE to cross connect RNP and CLARA. NRC of 2.326 euros and MRC of 538 euros
 - WHREN-LILA awardees agreed to cover charge for 1 year until permanent funding can be arranged



- Nov 05: Connected RNP at LILA East
- Nov 05: Established peering with RNP and Abilene using multihop BGP. Enabled HEPGrid in Rio and SPRACE in Sao Paulo to participate in SC05
- Dec 05: Cisco ONS released from Customs in Sao Paulo
- Dec 05: Participated in the 2005 NSF-EduCause CyberSecurity workshop
- Dec 05: Activated second GigE link in Tijuana. CLARA and CUDI each on dedicated GigE ports
- Dec 05: Cisco ONS installed and Open Exchange Point established in Sao Paulo (diagram)





Links Interconnecting Latin Americ

Sao Paulo / Miami - Via 2 x STM-4 / VC4-8c

(Current as of 8/14/06)



Year 1 Milestones Dissemination and Outreach

- Jan 05: Established WHREN-LILA newsletter to disseminate project information using mailers and web site
- Apr 05: Presented WHREN-LILA project at CUDI Spring meeting
- Jul 05: Inaugurated LILA West link at the Border Governor's meeting in Mexico
- Sep 05: Demonstrated at iGrid 05 bandwidth demonstrations (diagram)
- Nov 05: Participated in SC05 bandwidth challenge



iGrid 2005

 Ultralight collaboration involving U Florida, Caltech, U Michigan, CERN, CHEPREO, FIU, Brazil, Korea

 Utilized WHREN-LILA link from Miami to Sao Paulo

 Achieved 539Mbps flow inbound and 532Mbps flow outbound

16:00

34.62 Mb/s last

32.08 Mb/s last

LILA East

16:30

600 M 500 M

400 M

300 M 200 M

100 M

🔲 input

output

bits/sec



Current Year 2 status and future plans

- LILA Infrastructure
- Project Coordination
- Dissemination and Outreach
- AtlanticWave
- Western Hemisphere Exchange Points
- Monitoring and Measurement
- Security



Current Year 2 Status LILA Infrastructure

- Jan 06: Increased capacity to 1.2Gbps on LILA East link
- Feb 06: RedCLARA delayed interconnection in Sao Paulo until recognized as exclusive network operator for Central and South America
- Apr 06: Resolved all business issues between CLARA and FIU. CLARA agrees to connect at the Sao Paulo Exchange Point
- May 06: HEP groups in Rio and Sao Paulo connect to Sao Paulo exchange with GbE links
- Jun 06: Met with Matt & Matt on monitoring and measurement practices



Current Year 2 Status LILA Infrastructure

- Jun 06: Brazil utilizes LILA-east link to participate in CMS Tier2 bandwidth tests
- Jul 06: NSF CHEPREO funds LILA East bandwidth increase to 2.5Gbps in 2006
- Aug 06: RedCLARA connects at Sao Paulo Exchange. Peering established with Abilene
- Aug 06: Translight/PacificWave approved to extend CLARA and CUDI to PacificWave
- Sep 06: CLARA requests connectivity to AtlanticWave
- Oct 06: CLARA and CUDI connect to Pacific Wave over LILA West



Current Year 2 Status Project Coordination

- Sep 06: All-Hands meeting in Santiago, Chile
 - Engineering Track
 - Peering with U.S. NRNs
 - Connecting to PacificWave
 - Connecting to AtlanticWave
 - Policy Track
 - Encouraging research and education across the borders
 - Policy Discussion
 - Science Research Advisory Committee
 - All Hands
 - International R&E Peering
 - Monitoring and Measurement
 - Super Computing 2006



Current Year 2 Status Dissemination and Outreach

- Jan 06: Organized workshop on Biodiversity and CyberTools in Panama
- Jan 06: Presented at the launch of the Venezuelan Internet2 initiative
- May 06: Participated in RNP's networking symposium
- Sep 06: Brazil participates in data grid federation demonstration at OGF1



AtlanticWave



- AtlanticWave is provisioning a 10GigE wave to support a distributed international exchange and peering fabric along the Atlantic coast of North and South America, following the GLIF GOLE model
- AtlanticWave will connect the key exchange points on the U.S. East Coast:
 - International Exchange Points MANLAN in NYC and AMPATH in Miami
 - MAX gigapop and NGIX-East in Washington, DC
 - SoX gigapop in Atlanta
- A-Wave is an integral component of the NSF IRNC WHREN-LILA proposal to create an open distributed exchange and transport service along the Atlantic rim
- A-Wave partners include SURA, FIU-AMPATH, IEEAF, FLR, MAX, SLR/SoX, Internet2/MANLAN, and the Academic Network of Sao Paulo (ANSP)



Western-Hemisphere International Exchange Points

- Collaboration with TransLight and CANARIE to extend connectivity to StarLight and PacificWave
- International Exchange Points at Sao Paulo, Miami, Washington DC, NYC, Chicago, Seattle, LA
- Exchange and Peering capabilities with national and international networks







Solution to Proposed Objectives

- Improves network connectivity in the Western Hemisphere
- Promotes flexible and efficient peering through distributed open exchange points
- Leverages participants' network resources to foster collaborative research and advance education throughout the Western Hemisphere, to Europe and Asia



Monitoring and Measurement

- Link utilization using Crickett and MRTG
- End to End Performance Tools
 - Network Diagnostic Tool (NDT) @ AMPATH
 - Bandwidth Test Controller BWCTL
- Real Time Network Status
 - Nagios Monitoring Service (Access Restricted)
 - Round Trip Time Statistics
 - PingER Traceroute Server
 - PingER Advanced Ping Service
 - NTOP Network Usage Tool
- perfSONAR (working with I2 and IU)







Security

- Coordinate with the Global NOC and upstream and downstream networks and exchange points
- Inter-NOC collaboration and coordination on security practices
- High-degree of physical security at NAPs in Miami and Sao Paulo



Future Plans

- Exploit capabilities of distributed exchange point model
- Optimize coordination and communications processes among operations groups
- Participate in GLIF and GOLE initiatives to support evolution of international networking
- Foster creation of new pathways for north-south science and engineering research and education
- Support rational growth and cooperation throughout the Western Hemisphere



Future Implementation Goals

- Flexibility for end user requirements
 - ONS ML GigE ports assigned to individual end users to accommodate end2end flows (LHC experiments, network research)
 - To accommodate 2 x 1 Gbps flows and an additional 300 Mbps flow:
 - Circuit provisioned using 2 x STS-12c-2v (1 Gbps) VCAT groups, an additional STS-3c-2v (300 Mbps) VCAT group and/or multiple STS-1c-2v circuits over the STM-16 circuit.
 - sw-LCAS can be used to accommodate network dynamics. This means bandwidth can be re-provisioned while not affecting data flows.
 - Achieves: Granularity to 51 Mbps (I.e: efficient use of bandwidth)
- Traffic Engineering
 - Peers are can be guaranteed bandwidth at port speeds or given CoS via policing which ensures better than best effort availability for sensitive data flows
 - VLAN mappings can be preserved throughout; a combination of Ethernet Wire Services or Ethernet Relay Service can be implemented using ML card to ensure flow separation and data security/integrity



Sao Paulo / Miami - Via VC4-8c or Full STM-16

(Near Future)

Communities and Applications

- High-Energy Physics
- Computer Science
- Astronomy
- Earth Sciences
- International Grid communities
- Biodiversity and Ecological Research
- Genomics
- Education and Outreach



An International Grid Enabled Center for High Energy Physics Research & Educational Outreach at FIU





An integrated program of research, network infrastructure development, and education and outreach at one of the largest minority schools in the US

AWARD #0312038





UltraLight 10 Gbps

Gloriad

CERN-US links 10 Gbps

A next-generation hybrid packet- and circuit-switched dynamic network infrastructure

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- Partners: Caltech, UF, FIU, UMich, I2, SLAC, FNAL; UERJ, USP, ANSP, RNP; GLORIAD (cn, kr, ru), GLIF
- Strong support from Cisco, CENIC, NLR, FLR

Computer Science: L-STORE

L-Store provides a distributed namespace for storing arbitrary sized data objects.

Geographically distributed access to the data



www.reddnet.org



Gemini, NOAO, CTIO, SOAR International Collaboration

Gemini North & MK Observatories

Gemini Internal Operational Backbone

Gemini South & CTIO, SOAR



Radio Astronomy

- VLBI Very Long Baseline Interferometry

 VLBI ROEN Radio Observatorio Espacial del Nordeste
 - To be at 1 Gbps over 2.5 Gbps connection







Opening a University Fiber Highway Between Mexico and the US

- iGrid2005 Earth Sciences demonstration collaboration between SDSU, SDSC from the U.S. and CICESE and CUDI from Mexico
- A grid was formed by computer clusters running Linux at CICESE and at SDSC
- Utilized the WHREN-LILA west link, the compute servers from PRAGMA, and the SDSU Visualization Center



1Grid 2005

COLLABORATORS

- Carlos Casasus, CUDI, México, <u>ccasasus@cudi.edu.mx</u>
- Eric Frost, SDSU, US, eric.frost@sdsu.edu
- Dr. Gustavo Chapela Castañares, CONACYT, México,
- Dr. Federico Graef Ziehl, CICESE, México,

fgraef@cicese.mx

PRAGMA Institutions and Testbe



29 Resource Clusters from 26 institutions in 14 countries



Cindy Zheng, WCC2006, 8/20/2006

Proyectos GRAMA y PRAGMA



Cyberinfrastructure for International Biodiversity Research Collaboration Workshop

- Purpose: Examine trends where Cyberinfrastructure is likely to effect change in biodiversity research and ecological informatics - January 10-13, 2006, in Panama City, Panama
- Support and participation from 5 national science funding agencies: the U.S. NSF, Panama (SENACYT), Mexico (CONACYT), Costa Rica (CR-USA), Colombia (Colciencias)
- 60+ biology researchers, cyberinfrastructure technologists and funding agency directors from above countries, with participants from Guatemala, Puerto Rico and Peru
- Funding priorities, science collaboration objectives and the application of cyberinfrastructure to support those objectives were addressed



Award #0549456







http://www.ciara.fiu.edu/biocyber/index.htm

Sensor Networks to Restore Environmental Quality

Workshop Site: Buenos Aires, central hotel venue **Goal:** To bring together N. and S. American engineers and scientists to identify and pursue collaborative pathways for advancing environmental sensor network based science and technology

For example: **Sister rivers** projects as a test bed for new technology, nucleus for exchanging scholars, etc



International Collaborations in Cyberinfrastructure-enabled Genomics

Scope: Bring together N. and S. American scientists, practitioners and stake holders to identify issues and challenges, and pursue collaborative pathways for advancing cyber-infrastructurebased genomics science

Location: Universidad Peruana Cayetano Heredia, Lima Collaborative work on genome annotation can be enabled through cyber infrastructure





Education and Outreach

- Interdisciplinary Distributed Collaborative Learning Communities
 - CyberBridges and Global CyberBridges
 - PRAGMA
 - PRIME
 - PRIUS
- PASI: Cyberinfrastructure for International, Collaborative Biodiversity and Ecological Informatics
- Sigma Xi: Global Engagement Workforce workshop





CI-TEAM Demonstration



NSF Award # OCI-0537464 Oct 1, 2005 - Sept 30, 2006

Heidi Alvarez, PI CIARA Julio Ibarra, Co-PI CIARA Chi Zhang, Co-PI CS Eric Johnson, Co-PI CS

By understanding Research & Education Cyber Infrastructure, we will bridge the divide between IT and the Sciences

- 4 Science & Engineering Graduate Student Fellowships
- Research Stipend
- Tuition for Spring and Summer 2006
- CIARA IT Science Certificate
- Collaborative publication & conference participation



GRADUATE FELLOWSHIP OPPORTUNITY FOR SCIENCE AND ENGINEERING



NSF CI-TEAM Implementation Project: Global CyberBridges (GCB); A Model Global Collaboration Infrastructure for e-Science between US and International Partners, OCI-0636031

- Implementation project to improve the technology training for a new generation of scientists
- Collaboration with the Computer Network Information Center of the Chinese Academy of Sciences, the City University of Hong Kong, the University of Sao Paulo's School of the Future
- Global CyberBridges Fellows in each location will enhance their understanding of High-Performance Networking and Grid Computing Augmented e-Science and Engineering Research and Education



Interdisciplinary Research Internships and Cultural **Experiences**

ring the allebal work information Center 21st century NATIONAL SCIENCE FOUNDATION

(CNIC), Chinese Academy of Sciences

•Cybermedia Center (CMC), Osaka

Monash University, Australia



February 6, 2000

 National Center for High-performance Computing (NCHC), Taiwan Office of International Science and Engineering

University, Japan

Thinking Globally for the Cyberinfrastructure Workforce: In an effort to prepare young researchers for a meaningful place in the modern world of globalization and technological change, the Pacific Rim Undergraduate Experience Program (PRIME) at University of California/San Diego is giving qualified students a chance to participate in international research and cultural experiences.

PRIME is funded by NSF in cooperation with the Pacific Rim Applications and the Grid Middleware Assembly, a consortium involved in the advancement and use of very high-speed computation. During the program's first year, nine American computer science students received support to work with research teams at some of the world's leading institutions in that field - among them, Osaka University's Cybermedia Center in Japan, Taiwan's National Center for High-Performance Computing, and Monash University of Australia. They participated in projects ranging from computer-aided visualization to the remote control of experimental equipment, to distributed computing. In future years, the program will expand in scope even further, branching into research areas such as cardiac physiology and earthquake-prepared engineering.



Nine U.S. students participated in PRIME 2004 Credit: Peter Arzberger, Univ. of Calif/San Diego

Pacific Rim **Undergraduate** Experiences



Class of 2005

An international research and cultural experience to prepare

> **Application Deadline** February 24, 2006

Background and Motivation of PRIUS Pacific Rim International UniverSity

- Program at Osaka University
- Success of PRAGMA community
 - Accumulated Expertise and practice of building Highly advanced Grid applications and middleware
 - Formation of Human network of researchers and scie pacific rim



Maturity of PRAGMA R&D network

- Activation of Educational activities
 - PRIME: Providing UCSD students with an opportunity of experiencing, studying, and learning highly sophisticated technology and cultural background through practical R&D with PRAGMA partners.



Stimulating the movement toward the establishment of PRAGMA Educational network Pan-American Studies Institute (PASI): CI for International Collaborative Biodiversity and Ecological Informatics - Costa Rica

NSF Award# 0617469



Organization for **Tropical Studies**

where science and nature converge

- Expose students to advanced concepts in distributed networkbased science enabled by cyberinfrastructure tools
- Promote a new organizational form for doing science, that is collaborative and interdisciplinary
- Enhance students with a strong biodiversity or ecology background with distributed computing and research network tools for collaborative research





Assuring a Globally Engaged Science and Engineering Workforce Workshop

NSF People Goal:

A diverse, competitive, and globally engaged U.S. workforce of scientists, engineers, technologists and well-prepared citizens

What Information and Communications Technology Infrastructure Is Needed to Help Researchers Engage Globally?

- The panel examined the ICT infrastructures that will be needed for global research, education, and innovation in the future.
- What are the key characteristics of the CIT infrastructure to meet diverse needs?
- What institutional changes are needed to implement such an infrastructure?
- Organizer: Julio Ibarra, Executive Director of the Center for Internet Augmented Research and Assessment (CIARA), Florida International University Participants:
 - Philip Papadoupolus, Program Director, San Diego Supercomputer Center
 - Paul Avery, Professor, Open Science Grid, University of Florida
 - Charlie Catlett, Director, TeraGrid Project, Argonne National Laboratory



http://www.sigmaxi.org/global/overview/index.shtml

WHR

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Thank You!

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 - Academic Network of Sao Paulo, award #2003/13708-0
 - Southeastern University Research Association (SURA)
 - Florida International University
 - Latin American Research and Education community
 - The many national and international collaborators who support our efforts

