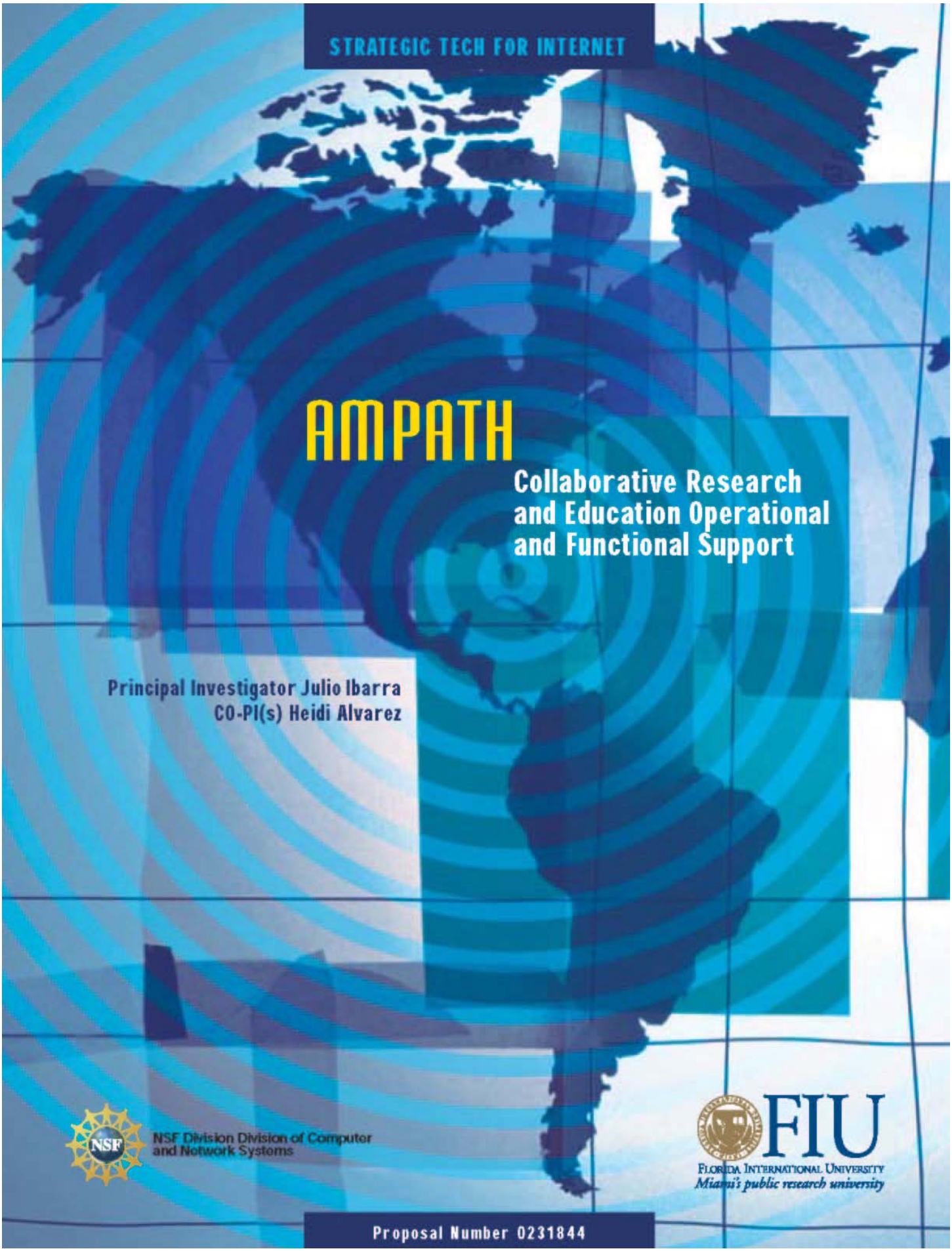

STRATEGIC TECH FOR INTERNET
AMPATH
Collaborative Research and Education Operational and Functional Support
Principal Investigator Julio Ibarra
CO-PI(s) Heidi Alvarez
NSF Division Division of Computer and Network Systems
FIU
Florida International University
Miami's public research university
Proposal Number 0231844

This page intentionally left blank

Table of Contents

1. Introduction

1.1 BACKGROUND

AMPATH (AMericasPATH) began in March, 2000 at Florida International University (FIU) in Miami. Its principal mission is to provide high-performance research and Caribbean in support of scientific collaboration and education. By August, 2001, AMPATH had already developed cooperative agreements with its industrial partners. These agreements included a three-year donation of ten DS3 (45 Mbps) circuits by Global Crossing valued at $25M. Other industrial partners by that time included Cisco Systems, Lucent Technologies, Juniper Networks and Terremark Worldwide. With these assets, AMPATH was able to connect two regional Research & Education Networks (RENs), Chile's REUNA and Brazil's RNP2. By April, 2002, AMPATH connected two more RENs, ANSP in Brazil and RETINA in Argentina, as well as the Arecibo Observatory (Arecibo PR) and Gemini South Observatory. In August of 2003 the research and education network of Venezuela was connected at the DS-3 level. Institutions in Peru are ordering connections at the E-1 level, and an impending connection to Panama. These achievements are the work of a very small AMPATH staff. The staffing at present includes just seven individuals who amount to less than four FTEs.

1.2 GOALS AND STRATEGIES

AMPATH seeks not only to provide high-speed connectivity between researchers and students throughout North, Central and South America. AMPATH also seeks to foster effective use of such connectivity for scientific and scholastic purposes, especially those of interest to the U.S. With this latter goal in mind, AMPATH has sought to (1) identify connectivity applications in the service area[1] of interest to U.S. science, and (2) foster collaborations between U.S. scientists and their counterparts in the service area.

1.3 VALUE TO U.S. SCIENCE

Although AMPATH seeks to strengthen science and education in its service area *per se*, it also seeks to enhance U.S. science and to foster closer research and educational ties between the U.S. and the service area. In this sense, AMPATH provides benefits in its service area similar to those already realized by high-speed NSF-sponsored connectivity to Europe and the Asia-Pacific Rim research networks. A number of U.S. science initiatives depend critically upon facilities or environments located in the AMPATH service area. One example is observational astronomy. Astronomical observatories located, or to be located, in the Caribbean and South America include Arecibo Observatory, Pierre Auger, the Gemini South telescope and the Atacama Large Millimeter Array (the latter two in Chile). Another example is the Inter-American Institute for Global Change Research (IAI). This intergovernmental organization coordinates research into environmental and socio-economic change in the Americas, and it counts 17 member countries in the AMPATH area as well as the U.S. and Canada. Also, NASA's International Space Station (ISS) project seeks to provide access to the

[1] Service Area is defined to be South and Central America, Mexico and the Caribbean.

ISS for scientific investigators worldwide, including those in the AMPATH service area. All of these U.S.-led initiatives now depend or will depend crucially upon high-speed connectivity between the U.S. and the AMPATH service area. Several federal agencies currently operate networks in Latin America using point-to-point low-bandwidth circuits. The AMPATH project can provide a coordinated and effective approach to these connectivity needs.

1.4 FUTURE NEEDS

AMPATH has developed so far with very minimal funding and personnel. Further development of the project and fuller realization of its goals will require more and different resources. The environment is quite nescient. The scope and benefit of increased focus is substantial enough that the European Commission has dedicated 10 Million Euros to better connectivity from Europe to Central and South America. While early observations were that the U.S. might be able to leverage this investment, the details of the EUAid package specifically prohibit networking with the U.S.

2. AMPATH Organization and Management

The AMPATH management team is chaired by Julio Ibarra, FIU, and includes representation from all collaborators. This committee makes policy and application support plans.

AMPATH

Chile

REUNA: Florencio Utreras
Connected June 2001

Argentina

RETINA: Carlos Frank
Connected December, 2001

Brazil

RNP2: Nelson Simoes (Rio)
Connected July 2001

FAPESP: Luis Lopez (Sao Paulo)
Connected March 2002

Puerto Rico

University of Puerto Rico: Guy Cormier
Connected August 2001

Venezuela

CNTI: Jorge Berrizbeitia
Connected April 2003

3. Operations

3.1 NETWORK INFRASTRUCTURE

The AMPATH network architecture, as shown in Figure 1, provides access to the wide area network provided over an ATM based Internet Protocol (IP) enabled network. Each national REN connects to AMPATH via this architecture. All AMPATH traffic routed to other international networks flows through the NAP of the Americas located in Miami, Florida. From Miami, the traffic is routed to either Abilene or STARTAP/StarLight. Abilene is the US-based research and education network, and STARTAP/StarLight is the ATM/optical exchange point for international traffic, located in Chicago.

AMPATH offers a variety of network services. Among the major services are:

- *ATM and Optical Ethernet peering fabrics*
- *Intra-regional peering over Layer 2 services, including IP VPNs*
- *Native IPv6*
- *Multicast capable*
- *End-to-end performance measurement and monitoring*
- *AMPATH Reflector VRVS server for Video over IP*
- *Flow based and QoS based monitoring using NetFlow tools capabilities*[2]
- *NOC Services through the Global Research NOC at Indiana University*

[2] Contingent on network engineer or programmer availability to provide customized reports

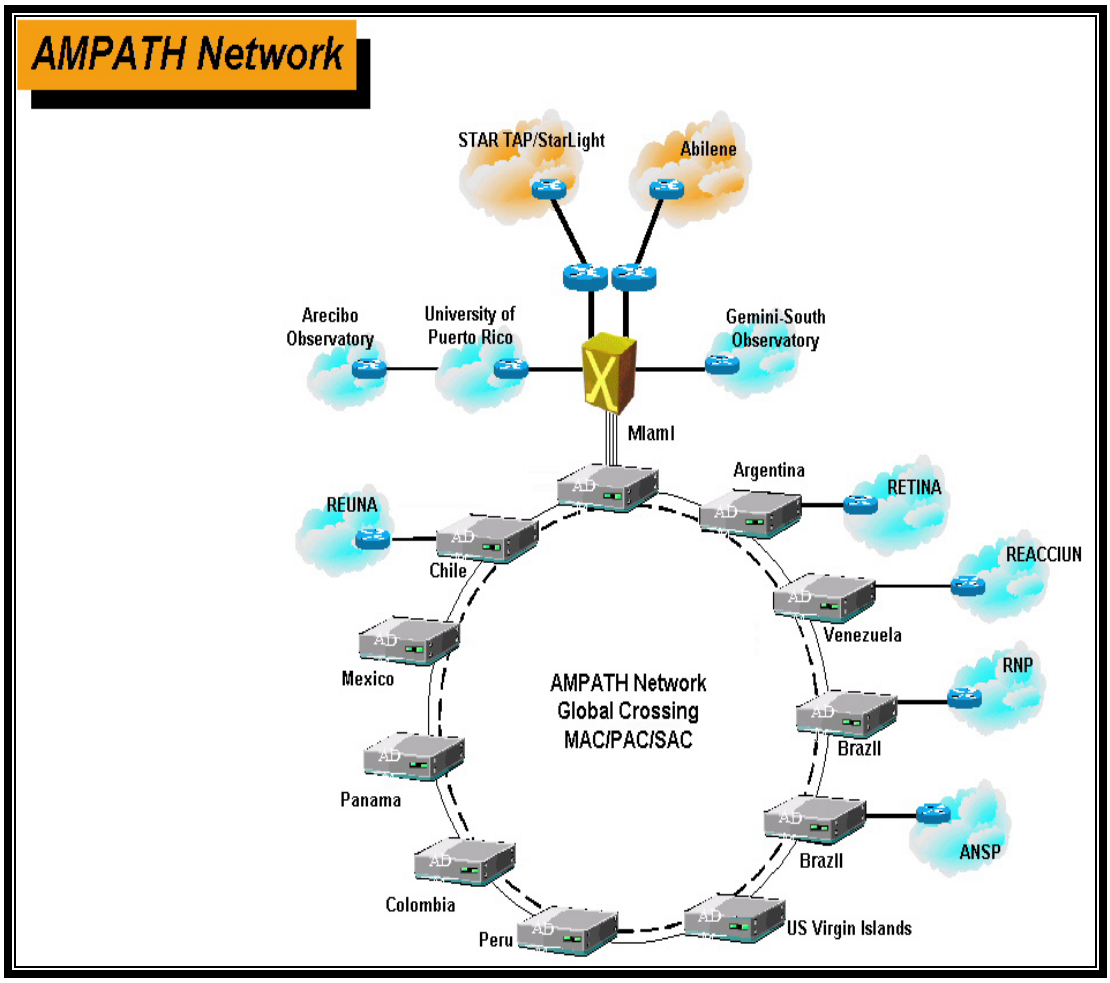


Figure 1: AMPATH Network Architecture and Connectivity

The figure above presents the basic network architecture employed by AMPATH. This architecture is representative of the research and educational networks worldwide. It also depicts the current AMPATH connectivity to the national RENs. As can be seen, the only interface between AMPATH and the rest of the world is through Miami to STARTAP/StarLight and Abilene. Through the STARTAP and Star Light interfaces in Chicago, virtually any location in the world is accessible to the national RENs .This interface is extremely important to the success of AMPATH in that it allows truly international collaboration to be conducted.

3.2 BUDGET

The operations of AMPATH are supported through NSF STI Award 0231844, Florida International University, Global Crossing and contributions from the management team.

Annual Costs:

Abilene Connectivity (622 Mb/s)	$180,000
StarLight Connectivity	$240,000
Local Loops in Miami	$177,000
Network Operations Center (Nap Of the Americas)	$ 24,000
Equipment Maintenance & Replacement	$160,000
Senior and Technical Staff	$185,000
Network Operations Services (Indiana University)	$ 25,000
Administrative Staff	$ 61,000
Travel	$ 120,000
Misc.	$ 28,000
Total:	$1,200,000

5 DS-3 Circuits	$4,200,000
	Provided by Global Crossing

Cost Sharing:

Chile	$120,000
Argentina	$ 70,000
Brazil	$240,000
Puerto Rico	$150,000
Venezuela	$120,000
NSF STI Award	$146,893
Gemini Project	$ 23,574
Florida International University	$329,533

4. Milestones

2000

April	AMPATH progress report at Brazil's national research networking conference, in Bello Horizonte, Brazil
August	AMPATH status report at the NLANR Joint Techs meeting in Toronto, Canada
Oct	AMPATH status report at Internet2 Member Meeting, Atlanta, Georgia

2001

June	Chile's Red Universitaria Nacional (REUNA) NREN connects to AMPATH; peering established with Abilene.
June	AMPATH status report at the STARTAP Annual Meeting, INET 2001, Stockholm, Sweden
July	Brazil's Rede Nacionale de Pesquisa (RNP) NREN connects to AMPATH; peering established with Abiline.
August 15-17	First NSF AMPATH Workshop for Identifying Areas of Scientific Collaboration between the US and the AMPATH Service Area, ANI-0123388.
August	University of Puerto Rico connects to AMPATH.
August 23-24	AMPATH Status Report at the HPIIS Workshop on Developing metrics to quantify the use of HPIIS network links, San Diego Supercomputing Center
December	Argentina's Red Teleinformatica Academica (RETINA) connects to AMPATH; peering established with Abilene

2002

March	Brazil's Academic Network of Sao Paolo (ANSP) connects to AMPATH; peering established with Abilene.
April	Gemini South connects to AMPATH; peering established with Abilene
April 12	First NSF International AMPATH Conference in Valdevia, Chile, ANI-0220176

May	AMPATH status report at International Task Force, Internet2 Member Meeting, Arlington, Virginia.
May	AMPATH status report at the Global Research Networking Summit, Brussels, Belgium
June	AMPATH establishes presence at the NAP of the Americas.
September	AMPATH enables native IPv6 and offers IPv6 peering to members.
October	NSF Strategic Technologies for the Internet Award for AMPATH Collaborative Research and Education Operational and Functional Support, ANI-0231844
October	AMPATH status report at International Task Force, Internet2 Member Meeting, Los Angeles, California.
December	University of Puerto upgrades to an OC3c its connection to AMPATH.

2003

January	AMPATH upgrades to an OC12c its connection to Abilene.
January	NSF AMPATH Workshop: Fostering Collaborations and Next Generation Infrastructure, ANI-0305876.
January	AMPATH status report at Internet2 Techs/ESCC Workshop in Miami, Florida, hosted at FIU.
February	AMPATH collaborates in the International Committee for Future Accelerators (ICFA) Standing Committee on Inter-regional Connectivity (SCIC) Digital Divide Working Group reporting on the Digital Divide in Latin America (http://icfa-scic.web.cern.ch/ICFA-SCIC/)
April	Venezuela's Centro Nacional de Tecnologias de Informacion (CNTI) connects to AMPATH; peering to Abilene established.
April	AMPATH status report at International Task Force, Internet2 Member Meeting, Arlington, Virginia.
April	AMPATH participates in REUNA's conference on research networking, in Chile.
May	AMPATH collaborates with US High-Energy Physics community to submit a proposal to the NSF Experimental Infrastructure Network program (proposal not funded).

May	AMPATH participates in RNP's Brazilian Symposium on Computer Networks, in Natal, Brazil.
June	AMPATH status report at the ACURIL conference in Puerto Rico.
June	Plan developed to connect the University of the Virgin Islands and the NRAO radio antenna on St. Croix to AMPATH.
September	AMPATH member meeting in Buenos Aires, Argentina.
September	NSF awards FIU to develop an inter-regional Grid-enabled Center for High-Energy Physics Research Education and Outreach, which includes partial funding for AMPATH to establish an STM-4 to Rio de Janeiro.
October	AMPATH status report at International Task Force, Internet2 Member Meeting, Indianapolis, Indiana.
October	Presented a paper on the Digital Divide in Latin America for the Digital Divide Round Table, at the International Center for Theoretical Physics (ICTP), in Trieste Italy.

5. Progress Reports

The following sections detail progress against the NSF ANIR STI project milestones. The STI proposal listed milestone activities organized by Infrastructure, e-Science Application Support and Outreach, shown in the proposal, in Appendix D of this report.

5.1 YEAR 1 WORK PLAN PROGRESS – JULY, 2002 THROUGH JUNE, 2003

5.1.1 INFRASTRUCTURE

Ongoing: Develop relationships with more international submarine cable carriers that offer service to other countries not serviced by Global Crossing.

ACTION: Engaged Latin American (LA) Nautilus to develop a customized solution for Bolivia. Worked with LA Nautilus' parent, Telecom Italia, to develop new infrastructure plans for the region. LA Nautilus has committed $100,000 to working with AMPATH in the next fiscal year.

ACTION: Began collaborative partnering with New World Networks, operator of the ARCOS submarine cable system, to identify opportunities in the Carribean.

ACTION: Signed memorandum of understanding with IMPSAT to offer AMPATH connectivity to additional locations in South America.

Ongoing: Connect the remaining NRENs or academic networks in Service Area countries where Global Crossing has a presence.

ACTION: Connected Venezuela.

ACTION: Developed interim connectivity solution for Peru, allowing key research universities to begin research collaborations through AMPATH.

ACTION: Finalizing MOU with Panama.

Ongoing: Determine how (and to whom) better connectivity will be provided

ACTION: Planning for upgraded connectivity for ALMA and research projects in Brazil.
ACTION: In discussions with the University of the Virgin Islands, the NRAO for connecting the VLBA antennae on St. Croix, and the telecommunications carriers that service the Virgin Islands.

Ongoing: Planning and overcoming turbulence in the carrier market

ACTION: Researched return on donation economics for Global Crossing. Demonstrating to all carriers that research and educational networking is a cost effective donation space.

ACTION: Working with Singapore Telemedia to establish the future position of Global Crossing after acquisition in the research and education networking space in the Americas.

Analyze and plan for instances where lambda communications will be necessary over the next 3 years and where existing or planned OCX connectivity is appropriate.

ACTION: Collaborated with Cal Tech to propose UltraLight for the NSF CISE Experimental Infrastructure Network program (Appendix G, declined); proposal was resubmitted to the MPS Physics at the Information Frontier (PIF) program. Working with AMPATH members to explore potential infrastructure increases.

Analyze and plan for improved or new AMPATH connectivity to other international connect points such as StarLight

ACTION: Procured AMPATH-STARLIGHT connection.

Centralize AMPATH in the NAP Of The Americas.

ACTION: Established AMPATH PoP at the NAP. AMPATH is presently distributed between the NAP and a nearby collocation facility. Procured fiber infrastructure to facilitate move. Move planned for 2004.

Upgrade Abilene connection from OC3c to OC12c.

ACTION: Completed upgraded to OC12c to Abilene.

Enable native Ipv6

ACTION: IPV6 supported to Argentina, Chile, and Brazil

5.1.2 SCIENCE APPLICATION SUPPORT

FIU/CMS HENP Outreach and Educational Initiatives working with Paul Avery and Harvey Newman, Pete Markowitz (FIU, Physics) and others to develop a work plan and funding proposal

ACTION: Proposed CHEPREO. Approved by the NSF Sep 1, 2003

Pursue resources AMPATH will need from funding agencies to fulfill its short and long term goals

ACTION: Proposed CIARA to ITR Medium Program. Declined.

Astronomy application advanced networking infrastructure support analysis through collaborative relationships with observatory PIs, Co-PIs and Sr. Personnel

ACTION: Developed ALMA plan.

iGrid 2002 Application Demonstration in HENP with Brazil using a 622 Mbps connection through AMPATH, StarLight, and SurfNET.

ACTION: Successful demonstration. Now routinely used in the HENP community.

Prepare addendum to NSF 96-15 CISE Minority Institutions Infrastructure Program for Building Globally Distributed Electronic Collaborative Learning Communities proposal

ACTION: Proposal submitted to the CISE MII program and was not funded. A subsequent proposal to the medium ITR program to develop a Global Grid-Enabled Collaboratory for Scientific Research (GEC-SR) was submitted in collaboration with Caltech and the University of Michigan; however, this proposal was also not funded.

Provide support as required to the Valdivia Conference Report Committee to complete and publish the conference deliverable to the NSF

ACTION: Published

5.1.3 OUTREACH

Prepare for the next AMPATH Meeting in Miami for necessary infrastructure support; video conferences with AMPATH participants and Advisory board member to plan relevant agenda items

ACTION: Conference and working groups meetings held.

Formalize AMPATH Advisory Board mission and guidelines

ACTION: Held first advisory board meeting in September. Efforts to formalize advisory board were deterred by confusion over European Union requirements with CLARA.

Assist in establishing Working Groups and Advisory Committees

- *Determine organization and structure, their missions, etc.*

- *Specify fields in which WG's will be created (Astronomy WG already has a chair); other fields include: high energy physics, possibly bioinformatics, environmental studies, genome studies, education, visualization, video conferencing*

  ACTION: Workshop facilitated progress. Working groups are proceeding without formal organization.

5.1.4 COMMUNITY BUILDING

Organize external advisory committee and identify its purpose; recruit subject matter experts.

ACTION: Instantiated CIARA framework. Developing advisory structure.

Schedule presentations to US and International agencies, including the Inter-American Development Bank, on the cultural impact of AMPATH, to increase in-country support for NREN's

ACTION: Active in both the Digital Divide initiative and the European Commission's @LIS.

Determine how best to engage AMPATH in the Institute for Connectivity in the Americas, which will support educational, cultural and scientific programs that connect the hemisphere.

ACTION: No action taken.

AMPATH presence at global networking conferences (such as INET), demonstrating AMPATH's commitment to global collaborations in scientific research and education

ACTION: Participation increased (please reference timeline)

Schedule demonstrations of intercontinental collaborative research and applications at national conferences, such as Internet2 Member Meetings

ACTION: INET presentation. AMPATH has facilitated demonstrations by Brazil at Super Computing and Internet2 Member meeting events.

Work with FIU School of Computer Science, I2 ATLAS program, and AMPATH participants to develop and propagate the AMPATH Registry on networks, applications, educational outreach initiatives in the Service Area .

ACTION: Begun work with Steve Luis, Associate Director of FIU's School of Computer Science.

Develop business plan integrating AMPATH and the GigaPOP. AMPATH will be the international exchange point for R&E networks between the US and Latin America, as service of the GigaPOP.

ACTION: Dissolved gig-a-pop to focus on AMPATH exchange point.

AMPATH Workshop, Miami Florida. Planning is already underway for this event which will feature new application developments, a focus on science discipline working groups output, and active planning by AMPATH participants .

ACTION: Meeting successfully held.

Develop and publish the AMPATH Annual Report

ACTION: This document.

6. Program Plan (2003-2004)

6.1 INFRASTRUCTURE

The infrastructure program is a very dynamic space. U.S. investigators need both more broad network access (to regions like the Caribbean) and more robust networking to collaborators and instruments in Brazil and Chile. The European Union's ALICE networking activity required the formulation of CLARA, an association of Latin American research and educational network managers. The result is that resources that some countries had previously allocated to connecting to the United States are being diverted to connect to Europe.

There is a hope that a regional network will be formed that can then peer with the U.S. The number of countries that would benefit and the levels of service are unclear.

There is increased demand for private Universities to connect to AMPATH.

The plan for this year is to work with additional carriers (beyond GX), scientist, and national research and educational networking bodies to develop a growth plan.

The U.S. has a clear leadership role in defining this Cyberinfrastructure.

Goals originally proposed and still planned include:

1. Connect to NRENs in the Service Area and academic networks of countries not serviced by Global Crossing

2. Conduct feasibility study to extend the AMPATH network and establish peering points in Service Area countries.

3. Continue planning of AMPATH's development as a production network for support of science and education, as well as an experimental network serving the application requirements of researchers from the US working in the Service Area.

4. Assess network equipment for AMPATH to develop a plan for replacement of obsolete equipment.

5. Replace obsolete equipment as per the recommendations in the capitol equipment replacement plan

6.2 E-SCIENCE APPLICATION SUPPORT

The AMPATH team has reflectively engaged a broad scientific community to determine what is and is not working with application support. For this research came the CIARA project. The CIARA project is a model that FIU and the University of Puerto Rico (UPR) are pursuing to increase the rate of discovery for investigators and improve graduate education.

The impact of CIARA is systemic. FIU has institutionalized the initiative, and collaborators from Lima to Sao Paulo are developing local versions. Appendix I describes the ITR oriented CIARA effort

Goals originally proposed and still planned include:

1. Continue development and administration of existing programs. Develop new programs based on e-Science requirements;

2. Cultivate educational outreach programs with US and Service Area research institutions for student and faculty exchange aimed an increasing minority participation in science and engineering disciplines that use or could use advanced international internetworking services.

6.3 OUTREACH

The network needs of U.S. investigators are growing rapidly in Latin America. The desire to collaborate on issues such as biodiversity and material science is exceeding the existing partnerships, and the scope of AMPATH. As outlined in Figure 2, the Caribbean basin has little to no infrastructure available for the far reaching research U.S. investigators are pursuing.

Figure 2 Bandwidth distributions in South America

The AMPATH team is committed to serving the needs of U.S. investigators. As a result, there will be a new focus on underserved areas such as the Caribbean, Bolivia, and Peru.

The previous format of AMPATH workshops served a needed scan of activities and interest areas. Planned activities for this year will focus on collaborations in particular disciplines, and around particular technologies.

Plans include:

A. Workshops on leveraging IPV6
B. A Workshop to promote US-ASIAN-LATIN AMERICAN cooperation
C. A PASI conference on Grid Computing
D. CIARA Application Support Workshops

The partnerships that are developing through CHEPREO in the high energy physics community will likely require significant increases in bandwidth, and thus facilitation on an effective model of utilization.

Appendix A: Papers and Presentations, International Meetings and Conferences

2000, April
AMPATH progress report at Brazil's national research networking conference, in Bello Horizonte, Brazil

2000, August
AMPATH status report at the NLANR Joint Techs meeting in Toronto, Canada

2000, October
AMPATH status report at Internet2 Member Meeting, Atlanta, Georgia

2001, June
AMPATH status report at the STARTAP Annual Meeting, INET 2001, Stockholm, Sweden

2001, August 15-17
First NSF AMPATH Workshop for Identifying Areas of Scientific Collaboration between the US and the AMPATH Service Area, ANI-0123388

2001, August 23-24
AMPATH Status Report at the HPIIS Workshop on Developing metrics to quantify the use of HPIIS network links, San Diego Supercomputing Center

2002, April 12
First NSF International AMPATH Conference in Valdevia, Chile, ANI-0220176

2002, May
AMPATH status report at International Task Force, Internet2 Member Meeting, Arlington, Virginia.

2002, May
AMPATH status report at the Global Research Networking Summit, Brussels, Belgium.

2002, September
Amsterdam, The Netherlands
iGrid2002 Meeting and Applications Demonstration

2002, October
AMPATH status report at International Task Force, Internet2 Member Meeting, Los Angeles, California.

2003, January

NSF AMPATH Workshop: Fostering Collaborations and Next Generation Infrastructure, ANI-0305876.

2003, January
AMPATH status report at Internet2 Techs/ESCC Workshop in Miami, Florida, hosted at FIU.

2003, February 8
International Committee for Future Accelerators (ICFA)
Standing Committee on Inter-Regional Connectivity (SCIC)
ICFA SCIC Digital Divide Executive Report

2003, April
AMPATH status report at International Task Force, Internet2 Member Meeting, Arlington, Virginia.

2003, April
AMPATH participates in REUNA's conference on research networking, in Chile.

2003, May
AMPATH participates in RNP's Brazilian Symposium on Computer Networks, in Natal, Brazil.

2003, June
AMPATH status report at the ACURIL conference in Puerto Rico.

2003, August
Operational Plan for Upgrading the Internet Connectivity of the United States Virgin Islands (USVI): University of the Virgin Islands (UVI), St. Croix VLBA Radio Astronomy Station and Other Research and Education Facilities

2003, September
AMPATH member meeting in Buenos Aires, Argentina.

2003, August 25
An In-Depth Look at AMPATH StarLight Traffic Accounting and Participant Analysis
A Report for the Strategic Technologies for the Internet (STI): AMPATH Collaborative Research and Education Operational and Functional Support Research Experience for Undergraduates, Award #331112

2003, October
AMPATH status report at International Task Force, Internet2 Member Meeting, Indianapolis, Indiana.

2003, October 23-24
Experiences with the Digital Divide in Latin America

Round Table on Developing Countries Access to Scientific Knowledge, The Abdus Salam ICTP, Trieste, Italy

2003, December 8-9
Role of Science in the Information Society
CERN Geneva, Switzerland

Appendix B: AMPATH Projects and Applications

B.1 High Energy Physics

The multi-TeV energy scales needed to advance the study of the nature of matter and its most basic interactions, and to search for new particles and forces, has led to unprecedented challenges in petabyte data access and analysis. This has led in turn to worldwide scientific collaborations where each nation contributes its share to the construction of the experiment, and to the resources needed to analyze the data, while participating in the global process of search and discovery. The Large Hadron Collider (LHC) program at CERN in Geneva, encompasses four major experiments searching for the Higgs particles thought to be responsible for mass, as well as the states of matter and violation of symmetries that existed in the early moments of the universe. The US is a major player in the two largest of these experiments, ATLAS and CMS, with approximately 400 US physicists and engineers (20% of the total) involved in each one.

The CERN/LHC program is a large, but not atypical, example of a collaboration-driven project[3]. The US has expended significant resources in this research area. The principal experimental devices are located in Europe, with major US contributions, and the Computational Data Grids that are being developed will be worldwide. Nevertheless, the program asks questions on such a grand scale that more than 5,000 individual researchers (in four large collaborations) are involved in working with various aspects of the problem. The Parallel and Distributed Processing Group of the Federal University of Rio Grande du Sul, in collaboration with its physics research staff, is an important player in the development of the Grid processing and data handling techniques necessary for the success of the LHC.

This collaboration is possible today in South America because of AMPATH.

B.2 Physical and Organic Chemistry

The University of Utah and the University of Buenos Aires are engaged in collaboration, funded jointly by the NSF and several Argentine agencies, to model chemical shifts in complex organic crystals. The collaboration itself is rooted in special expertise available in Utah and Buenos Aires. One of the objectives of the study is to develop robust techniques to include intermolecular effects in the calculations. Subsequently these techniques will be applied to solve structural problems in biologically active compounds from marine invertebrates from the South Atlantic in collaboration with researchers in the organic chemistry group and Buenos Aires.

B.3 Remote Biological, Marine, and Atmospheric Sensing

Although somewhat influenced by geography, the University of Puerto Rico's remote sensing program represents a collaboration of a different kind – one across many disciplines. This program acquires large, generally geographically-based, data sets from

[3] Although it faces a number of technical and human challenges because of the scale and scope of the scientific problems it is tackling, as well as the size of the collaborations themselves.

remote ocean sensing devices, earth-sensing satellites, and a variety of other sources. These data are then applied to problems in oceanography, marine biology, and a variety of related fields.

B.4 Biodiversity

Another broad collaboration dependant on AMPATH, based at the University of Buenos Aires and sponsored by IAI, is examining the role of biodiversity and climate in functioning ecosystems. The group is studying the interrelationships between the atmospheric composition, climate, land use, biodiversity, and the ecosystem as a whole and how that impacts on the provision of human services. This is a global program in terms of the systems studied and it relies on a collaboration between several senior scientists in six South and North American countries. Two of the participating researchers are in the United States, one in Mexico, and several more are in South America.

B.5 Materials Science

The Instituto Balseiro in Argentina is pursuing a program aimed at understanding the thermodynamic, phase stability, and transformation of complex material systems. This effort involves a broad collaboration involving research centers in Florida, France, and Sweden. It includes an important distance-learning component directed at the upper-division and graduate level.

B.6 Unique Facilities and Science Collaborations

Whether sponsored by the NSF, DOE, NASA, or other public or private agencies, today's major US science projects take on economic scales that innately require international participation through partnerships and other forms of collaboration. Thus, for many of these programs the interests of US science and policy are inexorably linked to the international communications infrastructure because the science is being done with internationally shared resources.

Many of the presentations spoke on actual, planned, or desired collaborations to share unique, one-of-a-kind or few-of-a-kind, research tools. There were many examples of in-place programs. The CMS experiment at CERN is a 144-institution partnership across 31 countries, and the ATLAS experiment is a collaboration of similar size and scope. The Gemini observatory is a seven-nation program, managed by the US (NSF), with three South American partners including Chile's CONICYT. The International Space Station is a 15-nation partnership. The UCD program consists of 17 partner nations in the Americas.

A number of other examples of currently active, planned, or desired programs had the same flavor. ALMA is a major international cooperative project involving the US, Canada, Japan, Chile, and the European Southern Observatory which, itself, has nine member countries. FIU has a center for electron microscopy that can be operated remotely from any part of the world and would like to establish a partnership to fund and operate a remotely accessible high-temperature and high-pressure physics laboratory. NASA/Ames would like to establish a similar facility for the analysis of a wide variety of

remote ecological, marine, and atmospheric sensor data, as would the University of Puerto Rico with oceanography data.

In many of these cases, the unique facility includes large expensive pieces of equipment, such as telescopes or particle accelerators. In every case, there were one or more remotely accessed shared databases or data archives. AMPATH is the connection to a number of these instruments today.

B.7 Video/Audio Communications

Videoconferencing, both for direct science collaboration and for operations purposes including data gathering, is becoming ubiquitous across AMPATH. Video over IP and Access Grid applications are becoming increasing common. The LHC experiments use the VRVS system for video/IP, including many meetings per day, throughout the year, as an integral part of the collaborations' daily work.

These technologies are especially useful adjuncts to programs involving remote operations or remote users, such as ALMA, Gemini, the University of Utah crystal modeling project with the University of Buenos Aires, and the International Space Station to mention a few. Some programs with multiple sites also mentioned integrating voice over IP into their telephone plants, as a convenience and cost-saving measure.

While some the systems use are already well-advanced[4], these will be developed into integrated environments for multi-site collaborative work; either on their own or in the context of Data Grids.

B.8 Remote Operations

Users through out the US manipulate and control observational or experimental equipment connected to AMPATH. Some described this as remote operation, and others as virtual operation[5]. In any case, there is a lot of cross coupling between remote data taking, virtual laboratories, and archival data analysis.

The Arecibo and Gemini observatories both make use of observing by scientists at remote sites as an alternative to astronomers having to travel to the telescope. It is intrinsic to Gemini operations, and they plan to expand the capability significantly, to include additional remote observing centers in Arizona, Florida, and Chile. Located at 16,000 feet, the ALMA observatory will have to be operated in this mode.

The NASA/Ames Ecosystem Computer Facility not only is engaged in the analysis of remote sensing data, put has a suite of analysis instrumentation that it plans to enable to allow remote analysis of remotely sensed data.

---

[4] As an example, the Virtual Room Videoconferencing System (VRVS) has 6100 registered computers in more than 50 countries. See http://www.vrvs.org.

[5] The word "virtual" is used somewhat ambiguously. As used here, the term means to collect the data in the first place through remote real-time intervention with the experimental equipment. However, it was also used by other presenters to refer to doing research using previously archived data at a remote site.

The Utah/Buenos Aires crystal project, the FIU study of the Andean rivers, and the International Space Station effort all require the remote manipulation of sensor equipment. NASA/Marshall has already developed a remote payload control packed for International Space Station PIs.

B.9 Virtual Laboratories/Observatories

This might be defined as doing remote science from centralized or distributed archives, libraries, and databases, using standardized suites of access and processing tools made for the purpose. One example of such tools is the FIU/NASA Regional Applications Center's Terrafly package that allows the overlay and moving-map visualization of multiple geographically-parsed data sets.

The Caltech/CERN/University of Buenos Aires Large Hadron Collider (LHC) collaboration expects to make extensive use of this approach. ALMA, Gemini, and Arecibo expect to participate in a collaboration called the National Virtual Observatory to permit the mining and analysis of various astronomy data sets with standardized tools.

B.10 Distributed Archives and Libraries

The CERN group will need to transport tens of Petabytes by 2006. The Space Station, ALMA, Gemini, and the Utah/Buenos Aires crystal programs all have multiple international archive sites.

The University of Puerto Rico's Tropical Center for Earth and Space Studies' satellite down-link facility maintains a large digital database of the tropical Western Atlantic Region that is accessed online by NASA and other federal agencies, universities, and the private sector. Ecological programs such as the FIU rivers project and other global change research projects like the Buenos Aires biodiversity and climate study all intimately rely on access to large data sets maintained in many different places.

The IAI global change data and information service project currently has two access nodes (Brazil and Uruguay) and expects to expand to 18 in the near future using AMPATH. This system uses a distributed network of libraries and databases accessed with a Yahoo-like search tool that yields relevant metadata and can provide ftp access if required.

B.11 Distributed Processing

The Federal University of the Rio Grande in Brazil has several programs that require distributed processing, including research in that subject itself, biological cell modeling efforts, 3D thermodynamic modeling, and high energy physics problems (with Caltech/CERN).

The Buenos Aires/LHC collaboration will take part in the GriPhyN network-based data-grid program, and will be part of the International Virtual Data Grid Laboratory (iVDGL) being supported by NSF. The FIU rivers project expects to use grid techniques in doing soil and fluids models. The Utah/Buenos Aires project expects to use grid processing in

its crystals program. Gemini and ALMA expect that grid approaches will become necessary in the future to handle complex image processing with large data sets.

Appendix C: AMPATH Performance Statistics

To effectively determine the effectiveness of a research and education network service, a review of the overall network performance should be made. The following shows current network use[6]. In Tables 2, 3 and 4, the data shows a constant flow consistent with what would be expected measured in a short timeframe. Table 5, however, shows a fairly constant trend that doubles by the end of the year.

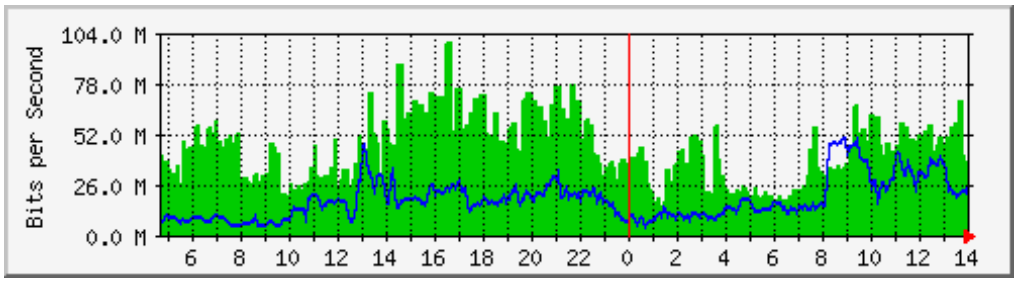


Table 2: Daily Traffic

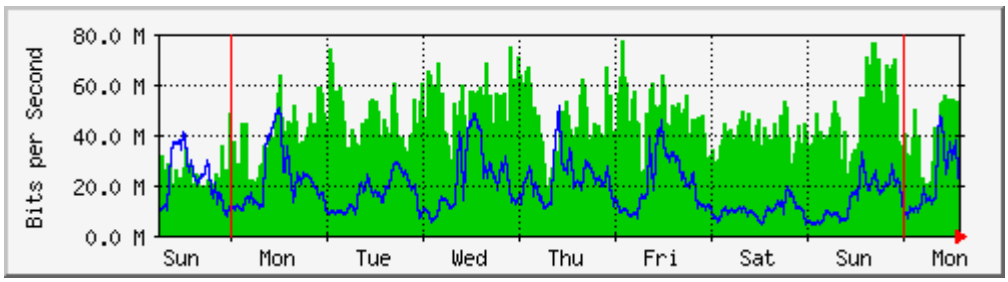


Table 3: Weekly Traffic

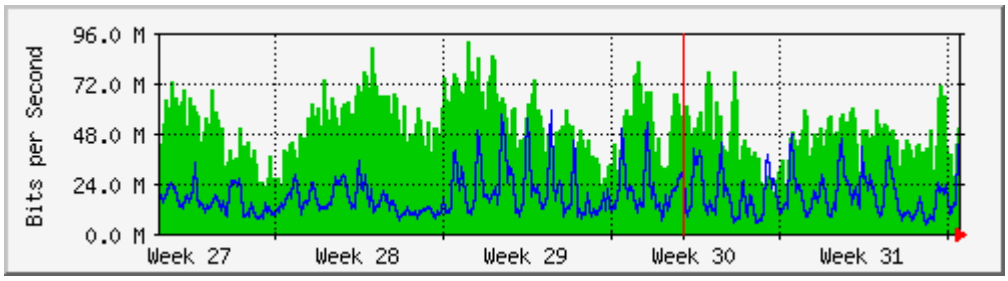


Table 4: Monthly Traffic

[6] Traffic measure available at http://www.net.fiu.edu/mrtg/ampathgsr.html

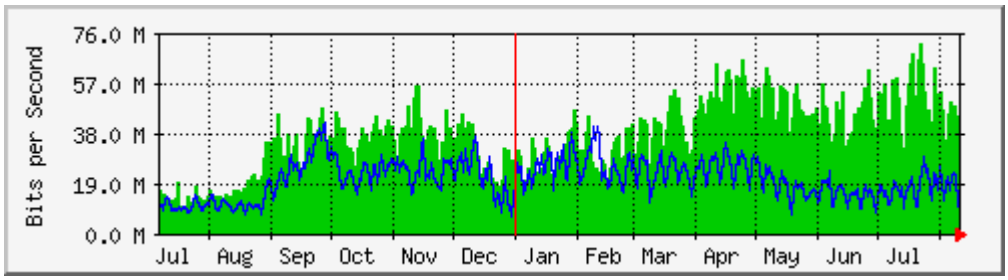


Table 5: Annual Traffic July 2001 through July 2002

Observations of AMPATH Annual Traffic

As indicated in Table 7, the annual traffic doubled during the measured year. As more users start passing traffic on AMPATH, the need to upgrade AMPATH will become more critical. As the awareness of AMPATH increases this growth may increase exponentially. The first step in addressing this growth is upgrading AMPATH's connection to Abilene. As stated earlier, AMPATH's initial OC3c was upgraded to an OC12c at the start of the 2003 calendar year.

Round trip time latency graphs are available for the REUNA, RNP2, and RETINA networks (shown below).

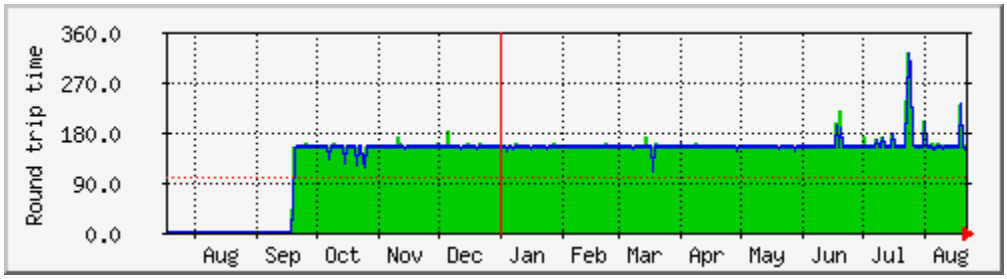


Table 6: REUNA Yearly Round Trip Latency Graph

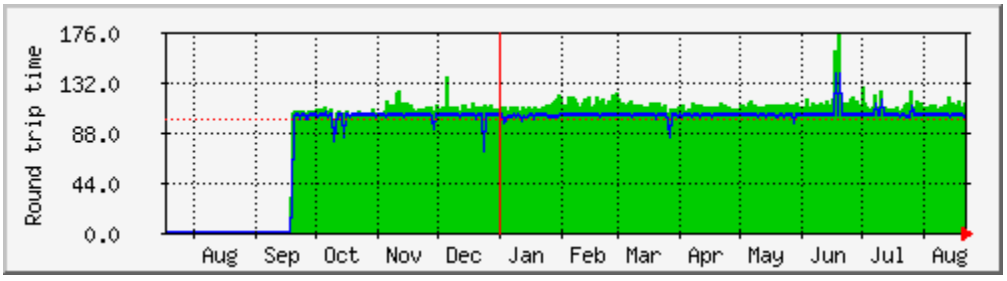


Table 7: RNP2 Yearly Round Trip Latency Graph

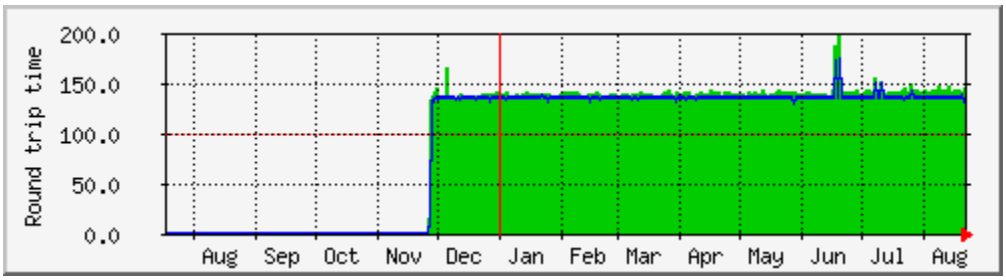


Table 8: RETINA Yearly Round Trip Latency Graph

Tables 6 through 8 demonstrate the stability of the connections to Chile, Brazil and Argentina. There is little variation on the round trip time latency for each of these connections.

Peering Statistics:

Site	Peer AS	Networks	Downstream AS's
AURA	AS19226	14 networks	1 AS
UPR	AS5786	97 networks	1 AS
ANSP	AS1251	28 networks	1 AS
RETINA	AS3597	39 networks	3 AS's
RNP	AS1916	87 networks	18 AS's
REUNA	AS11340	124 networks	2 AS's

Typical day (8-22-2002) observed 29797 unique IP addresses making use of the SFG/AMPATH connection. (Based on sampled Netflow data)

The above table shows how many autonomous system numbers and distinct networks are presently using the AMPATH network. On a typical day, 29,797 unique IP addresses sourced from these networks transited the AMPATH international exchange point.

Appendix D: STI Proposal

1. Introduction and Background

This proposal seeks staff support in order to improve the operational and functional capabilities of the AMPATH project, an advanced networking infrastructure and international exchange point for research and education, based in Miami, Florida at Florida International University (FIU). Assistance by way of salary support under the auspice of the NSF-STI-2002 program would have a direct and significant impact for AMPATH to address the STI goal of *accelerating Research and Development in strategic technologies*. AMPATH seeks to connect at least 10 countries' National or Regional Research and Education Networks (NRENS), as well as providing advanced networking connectivity to US e-Science applications and major instrumentation interests in Latin America, the Caribbean, the US and globally. A dedicated source of funding for the duration of this proposal will allow the AMPATH project team to carry out the future work plan proposed herein; directly reduce the cost-sharing requirements for its participants; and greatly assist collaborative research and information sharing between US scientific researchers, educators, using Internet based computational grids, and major research instrumentation. The proposal uses **The August, 2001 AMPATH Workshop Report**[7] prepared by a committee of US researchers, as the foundation of its funding request.

1.1 The AMPATH Project

Over the last two years, FIU has developed an international, high-performance research connection point in Miami, Florida, called AMPATH (AMericasPATH). One of AMPATH's goals is to enable wide-bandwidth digital communications between the Abilene network and ten National Research and Education Networks (NRENs) in South and Central America, the Caribbean and Mexico, as well as a variety of US research programs in the region.

FIU emphasizes research as a major component of its mission and is ranked by the Carnegie Foundation for the Advancement of Teaching as a Doctoral/Research University-Extensive, the highest ranking in its classification system. FIU has more than 32,000 students, 1,100 full-time faculty, and 90,000 alumni, making it the largest university in South Florida and placing it among the nation's 25 largest colleges and universities. It is unique in that it has the highest proportion of international students and faculty of any major university in the country. FIU is a Minority Institution with the largest contingent of Hispanic students of any doctoral-granting university and awards more Bachelors degrees to Hispanics than any other school within the continental US. Its mission includes being the principal educational and research interface between the State universities and South and Central America and the Caribbean. AMPATH provides

[7] http://www.ampath.fiu.edu/workshop.htm , The workshop was sponsored by NSF Award #ANI-0123388

opportunities for Hispanic minority students at the University to work on the project in technology and administrative positions.

Through the High-Performance Connections Grant solicitation of NSF's ANIR division, FIU first established itself as an Abilene connecting point for South Florida in 1999. In addition to itself, the University now provides Internet2 connectivity to Florida Atlantic University and the University of Miami. From this base, FIU realized that South Florida – because of the number of undersea fiber cables landing on its east coast and because it possesses a rich terrestrial fiber infrastructure - is strategically positioned to become a major international exchange point (IXP) for the research and education networks in South America, Central America, Mexico and the Caribbean.

To launch the AMPATH project, Global Crossing donated 10 DS3 (45 Mbps) circuits. AMPATH is providing one of these circuits to a NREN in each of ten service-area countries for three years to connect to the AMPATH IXP in Miami for connectivity to the Abilene Internet2 high-performance research and education network. The three-year period is staggered depending on the connection date of each NREN. Cisco Systems, Lucent Technologies and Juniper Networks donated carrier-class network equipment; and Terremark Worldwide, Inc. donated collocation space in the NAP Of The Americas. Since June 2001, the AMPATH project has connected three National Research and Education Networks in South America: REUNA[8] of Chile, RNP[9] of Brazil, and RETINA[10] of Argentina; the Academic Network of Sao Paolo, ANSP[11], which is a State-funded network; the University of Puerto Rico; the Arecibo observatory; and the Gemini-South telescope. The NRENs of Colombia, Mexico, Panama, Peru and Venezuela remain to be connected to the project. The final DS3 is to connect the R&E network of the US Virgin Islands, primarily targeted to the distributed campuses of the University of the Virgin Islands.

1.2 Current Cost-Shared Funding Model

AMPATH operates through significant industry support, with participants sharing the cost of operational expenses incurred by FIU in association with the project. The major cost-shared components are administrative staff support, network engineering personnel and support, hardware maintenance, and cost-shared bandwidth for Abilene and/or STAR TAP-StarLight. Several countries in the AMPATH service area have well-developed in-place R&E network infrastructures, at the national or state levels. However, for a number of others countries, the local telecommunications infrastructure build-out (the *local loop* or *last mile*) have been an economic challenge. Some of the potential AMPATH participants are struggling to build the financial commitment to join the FIU AMPATH project, obtain the equipment and collocation space in-country, as well as build out the local infrastructure to the universities and major research instrumentation, in support of US scientific research goals.

[8] www.reuna.cl
[9] www.rnp.br
[10] www.retina.edu.ar
[11] www.ansp.br

It is critical for the cost-sharing component to be significantly lowered or eliminated to allow the AMPATH international exchange point and network to mature. By providing the international connectivity at little or no cost for the first three years, participating countries will have the incentive and financial wherewithal to develop the in-country connections to universities and research centers needed for establishing stable NRENs. Moreover, all participants would have an opportunity to budget reasonable future costs for the international component of their circuits. Grant assistance, in the form of salary support, is being sought to offset these costs for a suitable period of time.

Please see http://ampath.fiu.edu/publications.htm
for the proposal project description

Appendix E: Starlight Traffic Analysis

An In-Depth Look at AMPATH StarLight Traffic Accounting and Participant Analysis

A Report By:
John D. Cabarga & Ernesto Rubi,
recipients of the National Science Foundation
Strategic Technologies for the Internet (STI): AMPATH Collaborative Research and Education Operational and
Functional Support Research Experience for Undergraduates
Award # 331112
August 25, 2003

**Supervised by Julio Ibarra, PI &
Heidi Alvarez, Co-PI**

Table of Contents

Please see http://www.ampath.fiu.edu/publications.htm
for the complete report with appendices

1 Introduction

The purpose of this report is to demonstrate the benefits of the StarLight link to both US FedNet participants and AMPATH international participants. The data analysis that follows will make evident a heavy usage by US FedNets and Latin American National Research and Education Networks (NRENs) connecting to AMPATH. The StarLight link is crucial in order to enable research traffic to flow between US Federal Networks (FedNets) AMPATH international participants since the Abilene Acceptable Use Policy (AUP) does not permit the transit of international traffic over Abilene to FedNets.

The current Gigabit link infrastructure handles IP, IPv6 and multicast traffic and since its inception in late January for the NSF sponsored workshop "Fostering Collaborations and Next Generation Infrastructure," has seen a traffic volume in excess of 3.44 terabytes (TB) an average of more than 400 gigabytes (GB) a month. With this type of usage it is safe to say the AMPATH StarLight link is a well established route of exchanging information between US FedNets and international peer networks.

2 Background

The AMericasPATH (AMPATH) network is an FIU project sponsored in part by the US National Science Foundation CISE directorate, in collaboration with Global Crossing (GC) and other telecommunications product and service providers. Using Global Crossing's terrestrial and submarine optical-fiber networks, AMPATH is interconnecting the research and education (R&E) networks in South and Central America and the Caribbean to US and non-US R&E networks via Internet2's Abilene network and the StarLight International Exchange Point.
The purpose of the AMPATH project is to allow participating countries to contribute to the research and development of applications for the advancement of Internet technologies. The mission of AMPATH is to serve as the pathway for Research and Education Networking in the Americas and to the World and to be the International Exchange Point for Latin America and the Caribbean R&E networks. Additionally AMPATH fosters collaboration for grand challenge e-Science and Educational Outreach to underserved populations both in the US and abroad.

The AMPATH pathway provides the 'bridging link' between Central and South America participant countries and the world's R&E networks. It is with this express purpose that the StarLight/STARTAP infrastructure was established. StarLight, the optical STAR TAP, is an advanced optical infrastructure and proving ground for network services optimized for high-performance applications[12]. The Science, Technology, And Research Transit Access Point, or *STAR TAP*, is a persistent infrastructure also funded by the National Science Foundation to facilitate the long-term interconnection and interoperability of advanced international networking. *STAR TAP* exists in support of applications, performance measuring and technology evaluations and connects with the Ameritech Network Access Point (NAP) in

[12] http://www.startap.net/starlight/ABOUT/

Chicago, enabling network traffic to flow to international collaborators from over 150 U.S. leading-edge research universities, institutions, and supercomputing centers.

3 Methodology

The data was collected using Cisco IOS's Sampled NetFlow feature on AMPATH's GSR 12012 router. Sample data was collected at intervals of 1 week each on two occasions; two one-day observations were also made. The first set was collected May 16th through May 22nd; the second set of data was collected June 1st through June 8th. Two more observations were made during June 24th and June 25th. These data sets not only cover two different months but also different time spans during both months. Information was collected purposely on non-overlapping dates to ensure that applications or regularly scheduled transfers from research centers would not affect our readings.

NetFlow is an accounting mechanism that is able to capture a large set of traffic statistics which include protocol, port, etc. These data sets can be further analyzed for purposes of planning, accounting, billing or network analysis. For this particular research project we used NetFlow to obtain readings of incoming and outgoing traffic from our AMPATH / StarLight link. Two distinct NetFlow commands were used.

First, to apply an input filter to the interface in order to gather the necessary data we used the NetFlow command:

flow-cat *filename* | flow-filter –I 62 | flow-stat –f9 –S2 | more

This command gives NetFlow the SNMP number of the interface which we want to analyze (in this case 62). For the output traffic analysis the NetFlow command:

flow-cat *filename* | flow-filter –i 62 | flow-stat –f9 –S2 | more

was used. Notice that in both of these commands we have omitted the true filenames of our observation in order to demonstrate that the various naming schemes can be in place. All NetFlow would need is the appropriate filename for the time period in which the observations are taking place.

Router configuration is also a crucial piece of the research taking place, since it is the router that samples the traffic that will later be analyzed. In our particular case AMPATH's router is configured for:

ip flow-export version 5
ip flow-sampling-mode packet-interval 100

From the above configuration we see that NetFlow v5 is being used; however, the most telling configuration aspect above is the sampling mode which looks at only 1 out of 100 packets. This interval allows for accurate traffic accounting while maintaining a safe CPU level. Tests using NetFlow v5 on the FIU campus by the University network engineers have demonstrated that a 1:1 sampling of traffic can be taxing to the equipment but moreover it does not differ greatly from the 1:100 sampling interval used for this report. The types of data transfers that we've looked at, specifically those that make the top 30 in terms of size of transfer, are captured

well with the setup described above. Abilene also configures their routers to maintain a 1:100 sampling rate for their NetFlow analysis. Having looked at these factors, we felt it was sufficient to maintain the sampling rate since it provided us with a safe guarantee of data integrity. There is one very important thing to keep in mind: when looking at the statistics for this interface, since the traffic was sampled at an interval of 1 out of 100 packets, the traffic figures should be multiplied by a factor of 100 once the analysis has been completed.

Not accounting for 'true traffic' will result in severely underestimated figures, which can have a definite impact on the research being carried out. One more convenient NetFlow feature is that it exports the sampled data from each configured interface to a destination specified on the router. In our case:

ip flow-export destination 131.94.191.101 2058

The above IP address resolves to a FreeBSD UNIX system that listens on port 2058 for incoming NetFlow exports from different devices on campus. The directory in which the data resides is located at: /raid/netflow/flows/gsr.ampath.net

Using these tools we are confident our data set represents an accurate record of traffic through the AMPATH StarLight link.

4 Traffic Accounting & Participant Analysis

With the information provided from NetFlow, we were able to find the IP addresses from each of our top daily users. All IP addresses are registered to their corresponding institutions and each one of these registrations also carries with it the pertinent contact information for each network. The contact information was obtained using a simple 'whois' command.

If during the course of our NetFlow analysis we obtained the IP 131.94.128.2 as one of the top daily users we would then proceed to find the information about this network/host using the following UNIX command:

whois 131.94.128.2@whois.arin.net

The above command queries a WHOIS server hosted by ARIN (American Registry for Internet Number) and returns information relevant to our study such as institution name, network block assigned and contact information for either network administrators or a Network Operations Center (NOC) that might be hosted by the participant institution. During the course of our study we found that not only was ARIN involved but also since hosts from all around the globe send traffic through this interface we had to query other registries. LACNIC (Latin America), APNIC (Asia-Pacific) among others were registries which we had to utilize in order to find the contact information for our participants.

After obtaining contact information for each participant shown on the NetFlow data, a formal letter was sent to each participant network explaining the purpose of our research project and how their participation in this research activity will help to ensure continued research and education along with advanced network connectivity.

In the letter we also asked that they visit a website in which some questions pertinent to our research would be asked. A separate letter *and* site was designed in Spanish, specifically for those users who would be more comfortable with Spanish than the original English version.

The English URL is:
http://www.florida.edu/ampath/application_info_req.asp

The Spanish URL is:
http://www.florida.edu/ampath/application_info_req_esp.asp

Both of these sites contain a brief survey form with specific questions regarding the nature of the research that participant institutions are undertaking. One such example of a question that can be found in our survey asked these institutions which other research networks they are currently peering with. This helped us discover where traffic/data from this particular user was going after connecting through the StarLight/AMPATH link. Another question asked was for specific contact person and contact information for that particular research institution. This helped us obtain another form of communication with our peer research networks other than the e-mail extracted from the simple 'whois' command issued based on the 'NetFlow' data.

Behind both of these ASP forms an MS-Access database will hold all submissions. With this database, we are able to receive data submitted by our users and utilize this information to further assist us with follow-up for this project.

***Data Observations**:*

In the most in-depth part of our report, we were able to analyze the data obtained into two distinct sets. The first set, which we will call 'first observation', refers to a one-week span, more specifically the third week in May 2003. Having used the NetFlow tool to obtain the IPs of the top 30 daily users for this period we created a set of seven MS Excel spreadsheets. Each one of these documents lists the top 30 users sorted by amount of bandwidth-utilized daily.

Having used the 'whois' UNIX command as previously described to gather information about each network, we were able to construct detailed tables describing the daily usage. Each daily table contains not only the IP of the member network connecting through AMPATH but also the name of the particular institution that the IP range is registered to. This way we were able to easily identify not only the participating universities and research centers but also aggregate to the national level. During data analysis of our first observation three different sections were considered. The first was the total amount of bandwidth used by the top 30 daily users; usually in Gigabytes. The second set that we considered was the usage totals by country (i.e. – Argentina 305 Mb), this helped set the stage for the final set of numbers which became evident; these were the percentage utilization of each member network during the period chosen for data analysis.

As an example, during May 16, our first day of observation, the total usage was a combined 9.7 Gigabytes. Brazil occupied the top spot with 72.9% of this total bandwidth; next the University of Puerto Rico used 9.8% of the total bandwidth and

next followed FIU, Chile (REUNA) and Argentina (RETINA) with 10.7%, 9.8% and 3.4% respectively. The following are the rest of the daily figures that we gathered at the conclusion of each observation: **

May 17th 2003:

Total Usage	*7,128,429,500*
Usage by Country:	
Brazil	*4,253,255,400*
Chile	*935,003,500*
UPR	*1,059,761,200*
Argentina	*292,744,200*
FIU	*457,853,200*
NASA	*129,812,000*
Usage Breakdown:	
Brazil	*59.7%*
Chile	*13.1%*
UPR	*14.9%*
Argentina	*4.1%*
FIU	*6.4%*
NASA	*1.8%*

May 18th 2003:

Total Usage	*12,534,095,400*
Usage by Country:	
Brazil	*5,988,536,500*
Chile	*1,077,280,700*
UPR	*5,031,446,600*
Argentina	*0*
FIU	*309,090,800*
NASA	*127,740,800*
Usage Breakdown:	
Brazil	*47.8%*
Chile	*8.6%*
UPR	*40.1%*
Argentina	*0.0%*
FIU	*2.5%*
NASA	*1.0%*

May 19th 2003:

Total Usage	*9,683,403,800*
Usage by Country:	
Brazil	*6,639,342,700*
Chile	*1,010,917,600*
UPR	*1,523,835,900*
Argentina	*0*
FIU	*325,905,600*
NASA	*183,402,000*
Usage Breakdown:	
Brazil	*68.6%*
Chile	*10.4%*
UPR	*15.7%*
Argentina	*0.0%*
FIU	*3.4%*
NASA	*1.9%*

May 20th 2003:

Total Usage	*10,790,991,300*
Usage by Country:	
Brazil	*4,707,947,200*
Chile	*3,750,741,700*
UPR	*338,315,600*
Argentina	*0*
FIU	*1,219,130,400*
NASA	*0*
Usage Breakdown:	
Brazil	*43.6%*
Chile	*34.8%*
UPR	*3.1%*
Argentina	*0.0%*
FIU	*11.3%*
NASA	*0.0%*

May 21st, 2003:

Total Usage	*11,023,778,000*
Usage by Country:	
Brazil	*8,665,916,300*
Chile	*747,051,300*
UPR	*1,080,695,500*
Argentina	*0*
FIU	*787,581,000*
NASA	*0*
Usage Breakdown:	
Brazil	*78.60%*
Chile	*6.80%*
UPR	*9.80%*
Argentina	*0.00%*
FIU	*7.10%*
NASA	*0.00%*

May 22nd 2003:

Total Usage	*6,724,536,800*
Usage by Country:	
Brazil	*4,626,194,600*
Chile	*490,556,000*
UPR	*1,282,814,400*
Argentina	*0*
FIU	*324,971,800*
NASA	*0*
Usage Breakdown:	
Brazil	*68.8%*
Chile	*7.3%*
UPR	*19.1%*
Argentina	*0.0%*
FIU	*4.8%*
NASA	*0.0%*

***Note: Since Brazil, Chile and Argentina had multiple institutions on the top 30 user list we made the decision to aggregate these into one country. Any time we refer to these countries we are really citing the multiple institutions that are connecting to Internet2 within the country.*

As we can see from our data observations, universities and centers transmitting data to AMPATH from South America upstream to the different FedNets have a large bandwidth footprint. On an average during this data collection period the top 30 hosts sent *9.645 Gigabytes* of data! Brazil was the heaviest user by far, representing on an average 61.2% of all traffic. UPR was second with 17.1% of daily traffic on an average. These two were followed by REUNA (Chile 13.5%); FIU (5.92%) and NASA hosts (0 .78%) along with RETINA (0.68%).

Our second observation consisted of analyzing not a half-duplex traffic situation as before, where only traffic being received from South American member networks was analyzed; but instead all traffic being sent and received by this link. The effect of studying traffic being received from StarLight was as expected, a fairly large collection of US FedNets and also international networks that frequent the AMPATH/StarLight link.
This second set of data was obtained during the first week of June, this was a time purposely chosen so that we could obtain data from non-overlapping weeks in different months. Traffic was analyzed in the same way as in the first observation, only this time our data samples were larger since we included all traffic across the StarLight router interface. Again we built tables with the particular IPs and names **of those top 30 users**

using the link; this time however, there was a slight difference in the analysis. Instead of breaking down traffic figures by countries as before, we decided to concentrate on the aggregate bandwidth being utilized by all top 30 daily hosts.

That approach yielded interesting results; and these are listed in our next table.

	Traffic (US FedNets and Beyond)	***Traffic (South Am. Member Nets)***
June 1st	*3,761,375,400 or 3.76 Gb*	*5,419,593,100 bytes or 5.42 Gb*
June 2nd	*16,276,361,200 or 16.28 Gb*	*16,723,112,700 bytes or 16.72 Gb*
June 3rd	*14,711,981,300 or 14.71 Gb*	*9,796,568,200 bytes or 9.79 Gb*
June 4th	*22,475,993,500 or 22.48 Gb*	*11,112,262,300 bytes or 11.11 Gb*
June 5th	*18,036,703,300 or 18.04 Gb*	*13,872,820,400 bytes or 13.88 Gb*
June 6th	*19,430,142,000 or 19.43 Gb*	*12,086,268,400 bytes or 12.1 Gb*
June 7th	*14,777,694,800 or 14.78 Gb*	*6,619,119,400 bytes or 6.62 Gb*
June 8th	*13,482,069,100 or 13.48 Gb*	*4,743,034,000 bytes or 4.74 Gb*
Average Traffic:	***15.37 Gb***	***10.05 Gb***

As we can see from the above results, the traffic from the US FedNets on an average outweighs the traffic being received from South American member networks. This is a very important fact to keep in mind; it underlines the usage characteristics of the various US FedNets and beyond. Worldwide, as shown in Appendix B, where the second observation results are located, universities and research centers frequently use this link as a means for research.

Another crucial part of our research that is still ongoing seeks to gather feedback from users of these member networks. Although feedback was still being gathered at the time this report was finalized, we will make it a high priority in our near future to append to this report, or any future publications, responses we obtain from researches who actively use this AMPATH/StarLight resource.

5 Current Network Layout

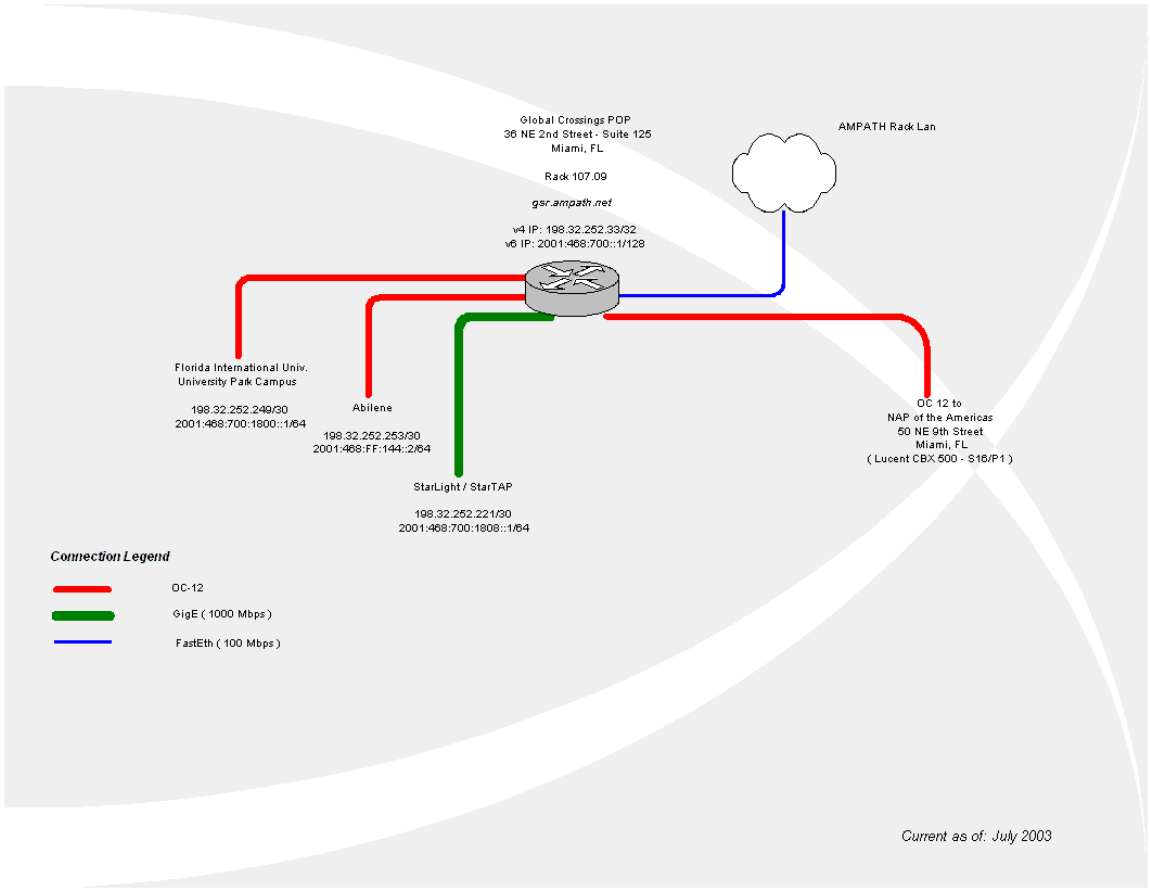
Please see *Appendix D* for a detailed network diagram and our current network schema. The AMPATH/StarLight link currently resides on the AMPATH GSR 12012 series, a donation from Cisco Systems, Inc. The link connecting AMPATH to Starlight is a Gigabit Ethernet link provisioned as a Layer 2 IP VPN tunnel over Global Crossing's MPLS private network. It is a Gigabit Ethernet link that is connected to StarLight via an MPLS cloud. This Layer 2 configuration permits end networks to conveniently establish bilateral peering relationships.

6 Conclusions / Recommendations

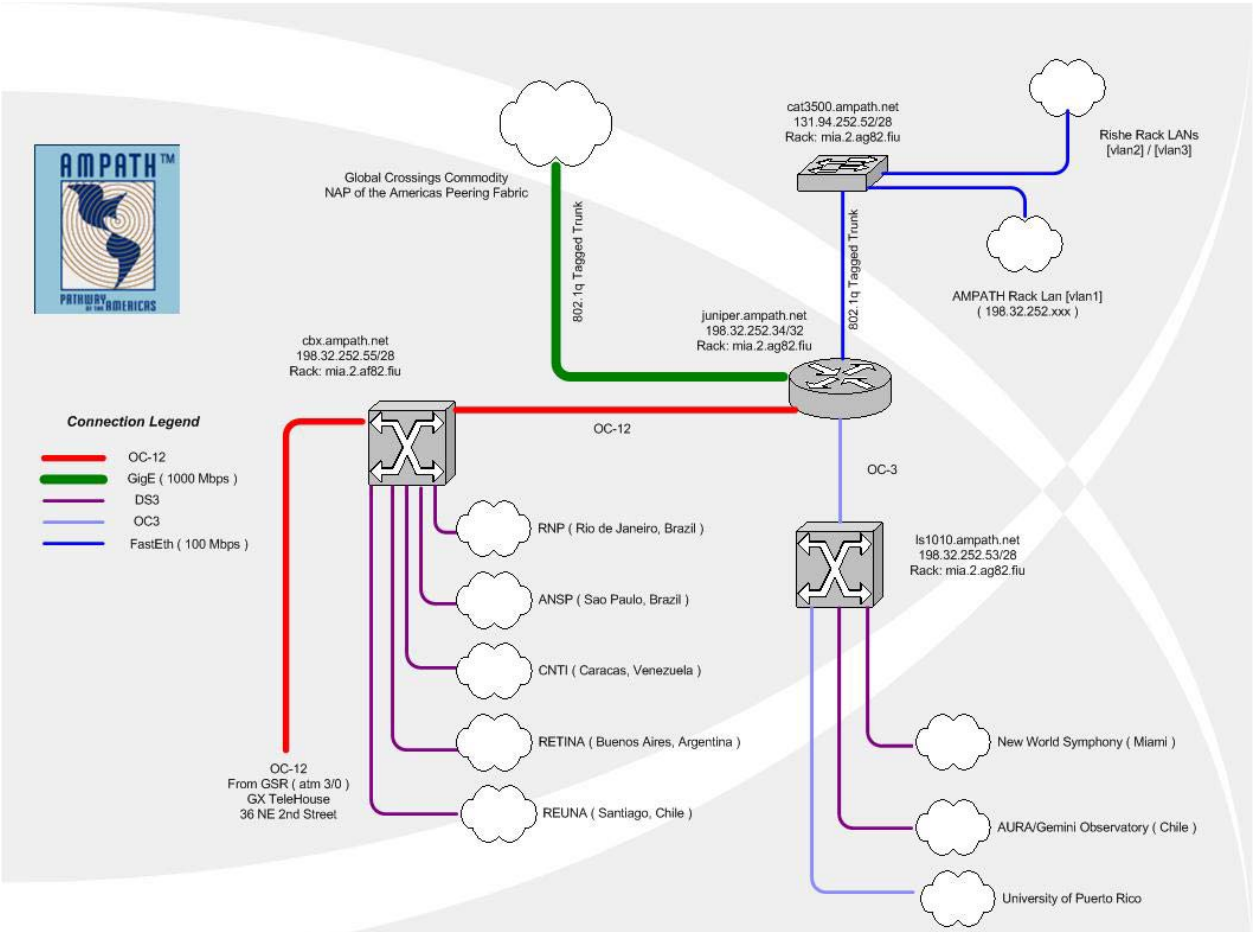
As is evident from the data gathered and analyzed we see a clear and consistent utilization of the AMPATH/StarLight link from US FedNets, international research organizations and universities. The extent of usage shown in the analysis of our observations warrants not only the necessary condition of a reliable link but the

establishment of funding sources that will guarantee the existence of this research tool. We therefore urge such funding be obtained, but also advocate the creation of an AMPATH/StarLight network procurement/reliability group once funding has been identified. This group would be immediately responsible for overseeing the network operations aspect of the connection and would then meet regularly to discuss improvements in order to also assure continued service; meaning no single point of failure on this link. Final network design and recommendations would be given to the appropriate entity and the network restructured to provide realization of this goal.

Appendix F: Current Network Diagram



***Shows GSR 12012 – Main AMPATH Router connecting to StarLight via GigE Interface.*



***Shows all Latin American NRENs connecting via AMPATH to US FedNets and Beyond (LS1010/CBX 500).*

Appendix G: ALMA Report

Cyberinfrastructure connectivity to ALMA

Summary:
The Atacama Large Millimeter Array is a major research instrument. The National Science Board has prioritized ALMA for National Science Foundation support. The ALMA project will require exceptional network infrastructure. There is an opportunity to deploy advanced network infrastructure for ALMA research and for networking research. The costs to deploy networks complimentary to the US Cyberinfrastructure would be approximately $1.4 million dollars per year. This cost is inline with international networking investments to CERN and other similar facilities of broad use. The current Experimental Integrated Networks program solicitation should be expanded in fiscal year 2004 to include support for international networking to major research instruments that the U.S. has an interest in.

Detail:
The Atacama Large Millimeter Array is a major research instrument. ALMA is an international collaboration between North America and Europe to build a millimeter-wave radio telescope system on the Atacama Plains of the Andes Mountains of northern Chile. This array will include 64 twelve-meter-diameter antennas working together to produce highly detailed images of astronomical objects. It will be the largest and most sensitive telescope in the world operating at millimeter and sub millimeter wavelengths. Such wavelengths are between those normally considered radio wavelengths and infrared wavelengths. ALMA is expected to be completed in 2011.

The National Science Board has prioritized ALMA for National Science Foundation support. In FY 2003, the NSF's Major Research Equipment and Facilities prioritized funding for seven projects is requested through the MREFC account. NSF's first priority is to continue funding of the following five projects initiated in FY 2002 and prior years: construction of the Atacama Large Millimeter Array (ALMA), the Large Hadron Collider (LHC), the Network for Earthquake Engineering Simulation (NEES), the South Pole Station Modernization Project (SPSM), and Terascale Computing Systems. The National Science Board's top priority for projects new in FY 2002 and FY 2003 (in alphabetical order) is ALMA, Earthscope, and NEON, as reported in the federal register.

The ALMA project will require exceptional network infrastructure. The ALMA will produce 20 times more data than the VLA. At average utilization the VLA *creates 140mega-bit-second* of outbound network traffic. The ALMA, used similarly would exceed three gig-a-bits of network utilization. Such network use is characteristic of only a handful of attached instruments. The distributed computation of that could be a component of ALMA, and is not of the VLA would exponentially increase the required

network bandwidth and the sensitivity to latency. This is a unique opportunity for research into protocols and techniques for sustained network effectiveness.

There is an opportunity to deploy advanced network infrastructure for ALMA research and for networking research. Florida International University through support form NSF ANIR has established a successful project to network Latin America, the AMPATH project. This project has established the effectiveness of circuits deployed internationally in the southern hemisphere. The investigators have established agreements with telecom infrastructure providers, and regional educational and research networking associations. This expertise, and existing infrastructure makes possible a dedicated light wave of connectivity from the U.S. to Chile. On the Chilean side this connectivity could be extended to ALMA with support from the ALMA construction budget. In the U.S. the light wave, which would terminate in Miami (predicated by existing carrier infrastructure), from Miami they could be connected to domestic infrastructure. The long network, with unusual latency characteristics, the steady rate of bandwidth transit, and the confluence of U.S. and Latin American network researchers offers a unique facility that can host experiments on effective high volume, long distance data transport.

The costs to deploy networks complimentary to the US Cyberinfrastructure would be approximately $1.4 million dollars per year. *The provision and interconnection of one lambda capable of Ethernet transport equal to 2.5 gig-a-bits per second would average $1.2 million dollars in recurring costs. By 2008 two lambdas should be available at the same price. One time costs may be near one million dollars, depending on the provisioning of network infrastructure between Santiago and ALMA. This infrastructure would be configured to be seamlessly part of the Terrascale Facility. Lambdas would be provisioned from Llano de Chajnantor, Chile to Miami, and on to Chicago. This would deliver the greatest value as part of a U.S. Cyberinfrastructure.*

This cost is inline with international networking investments to CERN and other similar facilities of broad use. *The annual NSF awards in the HIPPIS program to Trans Pacific networking is $2 million a year, for European Links the award is $2.2-2.4 million dollars a year, and for Russian networking $.8 million a year. The costs of providing advanced connectivity to the ALMA facility are within the previous commitment levels. The significant difference is the international networking connection is to access a U.S. instrument.*

The current Experimental Integrated Networks program solicitation should be expanded in fiscal year 2004 to include support for international networking to major research instruments that the U.S. has an interest in. *The NSB priority of the ALMA research project requires cross discipline action at the NSF. ANIR should seize the opportunity to enable ALMA and networking science and research to take place in harmony, all in the context of the Nations Cyberinfrastructure. An instrument to do this would be an expansion of the EIN solicitation for FY 2004. The expansion would fund international lambda connections of vital interest to U.S. science.*

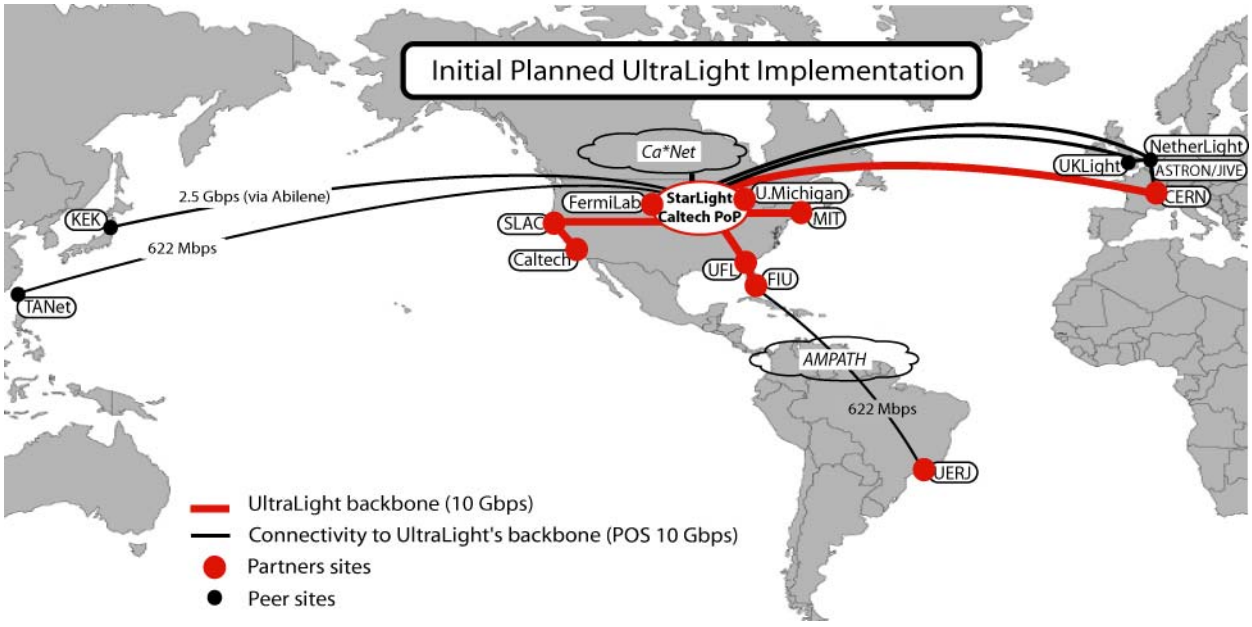
Appendix H: UltraLight Proposal

UltraLight: An Ultrascale Information System for Data Intensive Research

Submitted to NSF MPS/Physics: "Physics at the Information Frontier"
November 10, 2003

Proposal #0406515

Main Partner Sites	*Supporting Vendors and Organizations*
California Institute of Technology	Cisco Systems
University of Florida	Level(3)
Florida International University	National Lambda Rail/CENIC
University of Michigan	Internet2/UCAID
Haystack Observatory/MIT	DataTag/CERN
Stanford Linear Accelerator Center	AMPATH
Fermi National Accelerator Laboratory	CA*NET4
Brookhaven National Laboratory	UKLight/University College,London
	Netherlight/University of Amsterdam
	Translight
	HepGridBrazil (UERJ)



Senior Participants

Caltech
- Julian Bunn
- Philippe Galvez
- Iosif Legrand
- Steven Low
- Harvey Newman (PI)
- Sylvain Ravot
- Michael Thomas
- Frank van Lingen
- Conrad Steenberg

University of Florida
- Paul Avery
- Dimitri Bourilkov
- Rick Cavanaugh
- Alan George
- Chris Griffin
- David Pokorney
- Sanjay Ranka

Florida International University
- Heidi Alvarez
- Julio Ibarra
- Laird Kramer

University of Michigan
- Abhijit Bose
- Thomas Hacker
- Shawn McKee
- John Vollbrecht

Haystack/MIT
- David Lapsley
- Alan Whitney

University of California, Riverside
- Robert Clare

University of Chicago
- Robert Gardner

Boston University
- Jim Shank

UCAID
- Guy Almes
- Steve Corbato

Stanford Linear Accelerator Center
- Les Cottrell

Fermi National Accelerator Laboratory
- Lothar Bauerdick
- Don Petravick

Brookhaven National Laboratory
- Rich Baker
- Bruce Gibbard

Project Summary

Intellectual Merit: We propose to develop and deploy UltraLight, the first of a new class of integrated information systems that will support the decades-long research program at the Large Hadron Collider (LHC) and other next generation sciences. Physicists at the LHC face unprecedented challenges: (1) massive, globally distributed datasets growing to the 100 petabyte level by 2010; (2) petaflops of distributed computing; (3) collaborative data analysis by global communities of thousands of scientists. In response to these challenges, the Grid-based infrastructures developed by the LHC collaborations provide massive computing and storage resources, but are limited by their treatment of the network as an external, passive, and largely unmanaged resource.

UltraLight will overcome these limitations by monitoring, managing and optimizing the use of the network in real-time, using a distributed set of intelligent global services. These services will leverage Grid middleware, network-aware applications, and heuristic optimization algorithms, to form an integrated system that will meet the experiments' needs, while empowering data-intensive science over the next 10 years. The developments will be driven by, and will progressively serve the needs for Grid-based data analysis and production-processing, punctuated by a series of terabyte to petabyte LHC "data challenges" between now and 2007. The UltraLight hybrid packet- and circuit-switched network infrastructure will employ ultrascale protocols and dynamic building of optical paths to provide efficient fair-sharing on long range networks up to the 10 Gbps range. UltraLight's network protocols and path-building methods will protect the performance of real-time streams, enabling them to coexist with massive data transfers, and will ensure the overall high level of operational efficiency and robustness required to meet the major LHC milestones. Radio astronomers will also exploit the high speed data transport and bandwidth quality management capabilities for real-time and near-real-time correlations of very long baseline interferometric (e-VLBI) measurements. (e-VLBI work within the UltraLight project will be funded by the NSF Astronomy Division)

We will deliver these capabilities to the HEP and e-VLBI communities according to the following plan:

- We will deploy, in collaboration with industry and laboratory partners, a trans- and intercontinental optical network testbed, including high-speed data caches and computing clusters, with U.S. nodes in California, Illinois, Florida, Michigan and Massachusetts, and overseas nodes in Europe, Asia and South America. Ultrahigh speed data transfers on the UltraLight testbed will use advanced monitoring and management facilities (partially developed in this proposal) to provide the high level of performance, feedback and control needed by the experiments.
- We will use this new capability to create prototype computing infrastructures for CMS and ATLAS, broadening their existing Grid computing systems by promoting the network an actively managed component. In this new model, Terabyte-scale "data transactions" between sites will complete in minutes rather than hours, significantly improving the responsiveness of the distributed computing infrastructure, and enabling optimized resource sharing to accommodate hundreds of tasks with a wide range of priorities and data access patterns.
- We will closely couple UltraLight to the Grid-based physics production and analysis

systems under development in ATLAS and CMS. Physicists will use the testbed to further develop and instrument their physics analysis and production applications, and to exploit the powerful new architecture in order to meet near-term Grid analysis milestones and data challenges. Radio astronomers will also explore the potential for distributed correlation and processing of VLBI data using global Grid-based computing facilities.

Education, Outreach and Broad Impact: UltraLight's groundbreaking scope offers exciting and unusual educational outreach opportunities for students. It provides direct and significant support for E&O activities including: application development, experiment participation, infrastructure deployment, and internships at participating institutions. We will exploit existing outreach programs within the GriPhyN, iVDGL, and e-VLBI Grid projects as well as Florida International University's CHEPREO and CIARA programs to attract undergraduates to physics and math, and to inject new important elements of information technology into core graduate science domains.
As leaders of international Grid, networking and physics projects, we enjoy special access to major facilities in the U.S. and abroad, as well as the leading national and transoceanic optical networks. We will leverage the large and broad complement of expert personnel at our disposal, together with the efforts of our international partners and the exceptional support of major networking vendors (notably donations from Cisco Systems and Level(3)), to ensure UltraLight's success. Crucially, our alliances with our partners and major vendors will further broaden our impact.
UltraLight will enable new discoveries by the global LHC collaborations, and mark the entry into a new era of global real-time information systems where all three sets of resources – computational, storage and network – are monitored and tracked to provide efficient, policy-based resource usage. By consolidating with other emerging data-intensive Grid systems, we will drive the next generation of Grid and monitoring system developments, and new modes of collaborative work. Such unified information systems will serve future advanced applications in many disciplines, bringing great benefit to science and society.

Please see **http://www.ampath.fiu.edu/publications.htm** for the entire proposal.

Appendix I: CIARA

A Proposal Submitted to the 2003 ITR Medium Program Solicitation
By Florida International University & University of Puerto Rico

Heidi Alvarez – Principal Investigator, FIU
Julio Ibarra – Co-PI, FIU
George O'Brien – Co-PI, FIU
Guy Cormier – Co-PI, UPR
Oscar Moreno – Co-PI, UPR

Project Summary

Center for Internet Augmented Research and Assessment (CIARA)

IT innovations are 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 and the University of Puerto Rico, the two largest minority-serving institutions in the U.S. There is however 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. IT professionals are actively engaged in advancing applications of IT research. These applications are not effectively expanding the horizons for researchers and educators. The IT 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 IT.

We propose CIARA, a Center for Internet Augmented Research and Assessment, to be a new bridge between the existing disciplines and the IT community. CIARA will not be a locus for fundamental information technology research; it will create a new generation of scientists and engineers who are capable of fully integrating IT into the whole educational, professional, and creative process of diverse disciplines.

The goals are to increase the rate of discovery for faculty by augmenting their research with IT, to foster inter-disciplinary research, to improve the effectiveness of minority graduate education, and to institutionalize this change process.

The hypothesis is that evolving graduate student education to include a foundation of understanding in research and education IT will bridge the divide between the IT community and the disciplines. This will result in an improved system for the effectiveness, penetration, and interaction of IT with an underrepresented sector of our society.

Preliminary results indicate that the hypothesis has great potential for broad impact. At the core of the proposal is an opportunity for bringing together graduate students of diverse disciplines, and disparate academic communities. The larger the number of graduate fellows collaboratively building their understanding in research and education IT, the greater the opportunities are for cross discipline communication. By establishing two distributed and partnering CIARAs we propose to construct a matrix of these collaborations, with the expectation of exponentially increasing the benefits.

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 preliminary results. The research scientists involved at UPR and FIU have substantial experience managing projects of this scale, and track records of success in both the IT 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 at the centers. Both Universities view CIARA as a key part of institutional improvement, and are committed to long-term success pledging institutional commitment and **10% matching funds.** Genuine enthusiasm is spread across the faculty, students, and administrators, involved in proposing CIARA.

The assessment process will be the key to CIARA. Each graduate student will collaborate to author a scholastically grounded case study. This project will be designed collaboratively by the graduate student's advisor, the student and the IT research scientists associated with CIARA. This understanding will be facilitated through both an academic certification program, and a project that fuses IT innovation with domain specific research.

Please see http://www.ampath.fiu.edu/publications.htm for the entire proposal.