Experiences with the Digital Divide in Latin America

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Abstract

*In an era of global collaborations, and data intensive Grids, advanced networks are required to interconnect science and educational outreach projects seamlessly, enabling them to collaborate throughout the lifecycle of their work. For the major experiments, high performance networks are required to make possible Data Grids capable of processing and sharing massive datasets, rising from the Petabyte to the Exabyte scale within the next decade. However, as the pace of network advances continues to accelerate, the gap between the technologically "favored" regions and the rest of the world is, if anything, in danger of widening. This gap in network capability and the associated gap in access to communications and Web-based information, e-learning and e-commerce that separates the wealthy regions of the world from the poorer regions is known as the **Digital Divide**. Since networks of sufficient capacity and capability in all regions are essential for the health of our major scientific and education programs, as well as the democratization of global collaborations, we must encourage the development and effective use of advanced networks in **all** world regions* — International Committee for Future Accelerators (ICFA) Standing Committee on Interregional Connectivity (SCIS) Digital Divide Executive Report, February 8, 2003.

This paper draws on over three years of experience with the AMericasPATH (AMPATH) project to connect research and education (R&E) networks in Latin America and the Caribbean to US and non-US research and education networks to foster scientific and educational collaborations and outreach. Work on AMPATH has opened a window onto both the quantitative and qualitative implications of a gap in information technology research cyberinfrastructure and content in the region. We will show the aggregate bandwidth available to R&E networks as well as that which is actually provisioned for that purpose. Ultimately, we have learned that it is essential to bring the cyberinfrastructure directly to the end points, i.e. the scientific researchers, educators and students, to effect significant advances in the ability for globally distributed e-science collaborations to flourish. Success evaluation can be derived from statistics of number of collaborative papers published, funded research project collaborations, number of connected countries, networks and universities in the region. It is essential that we continue to build the cyberinfrastructure, as well as the social infrastructure to foster scientific collaborations and thereby provide a vehicle to reduce the digital divide.

Introduction

The purpose of this paper is to describe AMPATH's experiences with the Digital Divide in Latin America. First, this paper will provide background information about the AMPATH project, its goals and the work of the AMPATH team at Florida International University [1] (FIU) to facilitate access to the research and education communities of the countries of Latin America and the Caribbean to participate in

global scientific and educational activities. Second, a description of the network infrastructure in Latin America will be given, showing the bandwidth capacities in the Latin American region. This will be contrasted with the amount of bandwidth capacity that's being used by the research and education communities of each country to show where a divide exists.

As described in the ICFA SCIC Digital Divide Executive Report [2], what matters to the scientists conducting experimental work over a network infrastructure is the end-to-end performance of the network path. The network path is defined as (1) the Long Range (wide-area) Connection on national and international backbones; (2) the "Last Mile" Connection across the metropolitan or regional network, and; (3) the Local Connection across the university or laboratory's internal local area network. A bottleneck in any one of these three network path components will negatively impact the overall network path end-to-end performance. Cases will be described involving Brazil and Argentina where bottlenecks exist in at least one of these network path components preventing advancements in collaborative scientific and educational activities. Participants in this Digital Divide conference must suggest ways to help alleviate and, where possible, eliminate inequitable and insufficient broadband connectivity. As part of this process, this paper documents the existing bandwidth asymmetry in research and education networks in Latin America.

Removing bottlenecks from the end-to-end network path takes time and a lot of persistence. However, the social risk of marginalizing developing countries from the benefits of new technologies can be avoided by ensuring that their participation is central to field-level trials and dissemination strategies [3]. The HENP community has recognized the criticality of participation and inclusion of their peers in developing countries. They have motivated participation by conducting workshops, meetings, demonstrations and leaving behind operational networks as effective ways to raise awareness where there are bottlenecks preventing equal access and participation by researchers in developing countries [4]. FIU-AMPATH has joined the HENP community and is actively participating in collaborative activities aimed at reducing the digital divide in Latin America. Three of these collaborative activities will be described in this paper: (1) The inter-regional Grid-enabled Center for High-Energy Physics Research and Educational Outreach (CHEPREO); (2) UltraLight: An Ultra-scale Optical Network Laboratory for Next Generation Science; (3) The Center for Internet Augmented Research and Assessment (CIARA).

AMericas PATHway (AMPATH)

FIU, along with partial support from the National Science Foundation, has developed an international, high-performance research connection point in Miami, Florida, called AMPATH [5] (AMericasPATH). AMPATH was launched in March 2000 as a project led by FIU, with industry support from Global Crossing (GX), Cisco Systems, Lucent Technologies, Juniper Networks and Terremark Worldwide. One of AMPATH's goals is to enable wide-bandwidth digital communications between Internet2's Abilene [6] network, the StarLight [7], and ten national RENs in South and Central America, the Caribbean and Mexico, as well as a variety of US research programs in the region. AMPATH uses undersea and terrestrial optical-fiber networks to interconnect the Research and Education networks from each participating country to Internet2 and Next Generation Internet (NGI) networks in the US and other countries. A goal 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.

Since June 2001, AMPATH has connected four National Research and Education Networks in South America: REUNA[1] of Chile, RNP[2] of Brazil, RETINA[3] of Argentina, and REACCIUN[4] of Venezuela. Also connected to AMPATH are the Academic Network of Sao Paolo, ANSP[5], which is a State-funded network; the University of Puerto Rico[6]; the Arecibo[7] observatory; and the Gemini-South[8] telescope. AMPATH is working on connecting the R&E networks in Colombia, Panama, Peru and the US Virgin Islands [8]. AMPATH is one of five international peering points[9] in the continental US. Located at the

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[1] http://www.reuna.cl
[2] http://www.rnp.br
[3] http://www.retina.edu.ar
[4] http://www.cnti.gov.ve/, http://www.ampath.fiu.edu/cnti_news_eng.htm
[5] http://www.ansp.br
[6] http://www.upr.edu/
[7] http://www.naic.edu/
[8] http://www.gemini.edu/
[9] http://international.internet2.edu/intl_connect/index.html#moreinfoxp

NAP of the Americas[10] in Miami, Florida, AMPATH has evolved into an international exchange point for research and education networks.

Recognizing FIU's capabilities to serve as a pathway to help bridge the technology divide between the Americas, the US National Science Foundation has supported AMPATH to conduct workshops [9, 10, 11] to identify areas of scientific collaboration between the US and the countries of South and Central America, the Caribbean and Mexico. The workshop reports document the science and research that is taking place that is of strategic importance to the US and other nations. Presentations and reports from the two most recent workshops have raised awareness of just how much of a divide exists for access to high-performance bandwidth for Latin America's research and education community.

Network Infrastructure in Latin America

There are at least nine submarine fiber-optic cable systems that connect the countries of Latin America and the Caribbean region with North America and other continents. Table 1 shows nine of these cables landing on the southeast coast of Florida and their respective bandwidth capacity.

Submarine Fiber-Optic Cable System	Total Bandwidth Capacity (GB)
Americas 1	.560
Americas II	2.5
Global Crossing's South American Crossing	1,280
Columbus II	.560
Columbus III	2.5
Telefonica's Emergia	1,920
ARCOS	960
Maya-1	60
360 Americas	10

Table 1 Submarine Fiber-Optic Cables to Latin America and the Caribbean

The total aggregate bandwidth capacity into this region is estimated at 4,236 GB. There is a striking disparity between the amount of available bandwidth and how much is being used by the research and education community in the countries of Latin America and the Caribbean. For many countries in South and Central America, Table 2 describes the characteristics of their national research and education networks. Except for the countries connected to AMPATH (Argentina, Brazil, Chile and Venezuela) external bandwidth capacity to outside of the country is mostly unknown or non existent.

Researchers in countries that are connected to AMPATH continue to not have adequate access to bandwidth to collaborate with peers. Cases involving Brazil and Argentina are now described showing how the end-to-end path connection fails to reach the necessary end point – the researchers.

There are many Brazilian institutions collaborating with all LHC experiments: UERJ, UFRJ, UFBA, USP, UNESP and CBPF. Up until 2001, the connection between UERJ and Rede-RIO, the State of Rio de Janeiro's research and education network, was 2 Mbps. After a lot of effort, UERJ's connection was finally upgraded to a meager 8 Mbps. This rate still does not allow UERJ's HEP group to conduct important work with its international collaborators. Additionally, this link is now saturated with the university's general network traffic, without even including traffic originated by HEP group's experiments. Many of the other universities listed above face the same conditions as UERJ. Clearly, if this situation does not improve, the consequences for sciences in Brazil, and in particular for High Energy Physics, will be disastrous. Beyond the HEP projects in UERJ and at other Brazilian universities, there are many projects in other domains that are halted due to inadequate access to network resources [2].

Argentina has 56 institutions connected to its national research and education network, RETINA, of which 42 are universities and higher-education facilities, 8 are research institutions, 5 are governmental offices and public services. It is estimated that RETINA reaches 80% of the Argentinean research community. The bottleneck in the end-to-end path is typically the last mile connection from the universities to the RETINA backbone; many last mile connections are 2 Mbps of capacity. One of Argentina's public technological universities is the Universidad Tecnológica Nacional (UTN), Argentina's National Technological University. UTN has more than 30 campuses distributed throughout

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[10] http://www.napoftheamericas.com/

the country and more than 60,000 students, 40% of them are enrolled in Information Systems degree courses. To offer distance learning courses between its campuses, UTN primarily uses ISDN and frame relay for inter-campus communications, because it's less expensive than IP-based circuits. For all of its 30+ campuses, UTN uses a 2 Mbps connection to the commercial Internet and a 2 Mbps circuit to RETINA for connectivity to AMPATH and Internet2, for which it pays a premium.

Country	Organization	Existing REN?	National connections	External Capacity	Number of Connected Sites	Connection to US Internet2
Argentina	RETINA	yes	256Kbps – 34 Mbps	59 Mbps	56	yes
Bolivia	BOLnet	yes	64 – 128 Kbps	1.5 Mbps	18	no
Brazil	RNP	yes	2 – 30 Mbps (backbone up to 622 Mbps	202 Mbps	369	yes
Chile	REUNA	yes	155 Mbps	45 Mbps via AMPATH	18	yes
Colombia	RedCETCol	Not known	Not known	Not known	Not known	Not known
Costa Rica	CRNet	yes	32 – 512 Kbps	Not known	34	no
Cuba	RedUniv	University Network	19.2 Kbps – 2 Mbps	Not known	23	no
Ecuador	FUNDACYT	In planning	Not known	Not known	Not known	no
El Salvador	CONACYT	In planning	Not known	Not known	Not known	no
Guatemala	Not known	Non-existent	Not known	Not known	Not known	no
Honduras	HONDUnet	Not known	Not known	Not known	Not known	no
Nicaragua		Not known	Not known	Not known	Not known	no
Panama	PANNET/ SENACYT	University Network / Government Network	256 – 512 Kbps	1.54 Mbps	11	no
Peru	CONCYTEC	In planning	Not known	Not known	Not known	no
Uruguay	RAU	yes	64 Kbps to 1 Mbps	6 Mbps	46	no
Venezuela	REACCIUN	yes	Not known	45 Mbps via AMPATH	78	January 2003

Table 2 Summary of research and education networks characteristics in 17 Latin American countries [12]

Activities Aimed at Reducing the Digital Divide in Latin America

The Center for High-Energy Physics Research and Educational Outreach (CHEPREO) [13] is an NSF-funded activity (0312038) that will provide an inter-regional Grid-enabled integrated program of research, network infrastructure development, and education and outreach at one of the largest minority schools in the US. CHEPREO will create a robust outreach activity based on CMS research, develop and advanced networking and Grid computing infrastructure by joining the International Virtual Data Grid Laboratory (iVDGL) [14] and contribute with the partner institutions to the development of a global Grid laboratory while extending the iVDGL to South American countries through the AMPATH research network.

UltraLight: An Ultra-scale Optical Network Laboratory for Next Generation Science [15] is a collaboration and a cooperation among US and international institutions to develop and deploy the first integrated packet- and circuit-switched hybrid experimental research network to meet the data intensive needs of next generation science, engineering and medical applications, and to drive the development of a new generation of globally Grid-enabled distributed systems. The UltraLight project will develop a global optical network testbed, and scalable distributed storage and Grid systems, integrating and

leveraging the major facilities of LHCNet and DataTAG with transcontinental 10 Gbps wavelengths from National Lambda Rail, in research partnership with Starlight, UCAID, Cisco and Level(3). Additional trans- and intercontinental wavelengths in our partner projects TransLight, Netherlight, UKlight, AMPATH, and CA*Net4 will be used for network experiments on a part-time or scheduled basis, with extensions across Abilene, to Taiwan and Japan in Asia, and across AMPATH to South America.

Center of Internet Augmented Research and Assessment (CIARA) [16] seeks to increase the rate of discovery for scientists by augmenting their research with Information Communications Technology (ICT), to foster inter-disciplinary research, to improve the effectiveness of graduate education in underrepresented sectors of society, and to institutionalize this change process. 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. Enabled by AMPATH and the inter-regional Grid infrastructure provided by CHEPREO, FIU, the University of Sao Paolo (USP) and the State University of Rio de Janeiro (UERJ) are partnering to create peer CIARAs through a FIPSE[11] grant.

Conclusions

Scientific research is increasingly collaborative between institutions and countries. In 1995-97, scientists in the US co-wrote articles with scientists from 173 other countries, scientists in Brazil with 114, in Kenya with 81, in Algeria with 59 [3]. The 2003 ICFA-SCIC Digital Divide Executive Report [2] emphasizes the need for more inter-regional collaboration on projects enabled by Grid-based technologies as a way to bridge the inter- and intra-regional divide. We are encouraged that CHEPREO, UltraLight and CIARA will create new opportunities to build more bridges, further reducing the digital divide.

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