



Internetz evolution & AMPATH  
- the high performance  
international exchange point  
in Miami—  
*Facilitating peering for  
research & education  
networking*

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Florida International University  
July 23-24, 2008 Curacao



# Presentation Agenda

- Quick Overview
- Internetz Connection Reaches Who, What and Where?
- Other U.S. & Global Research & Education Networks
- AMPATH International Exchange Point in Miami
- Caribbean R&E Network Special Interest Group
- Applications



# Quick Overview

- What are National Research and Education Networks and why?
- What relevance do they have to developing countries?
- How are they created and where do they exist?

# What are National Research and Education Networks (NRENs)?

- Interconnect a country's higher education institutions
  - and often government research institutions, primary and secondary schools, libraries, hospitals, museums, other public institutions
- Provide a dedicated network
  - Separate from the commercial Internet
  - With dedicated connections to other countries' NRENs

# Why NRENs?

- Pool demand, resources, expertise of the research and education community
- Optimize network infrastructure for particular needs of research, teaching, learning
  - Keep traffic local
  - Provide uncongested bandwidth
  - Provides services like multicast to support multi-way video-conferencing
  - Provide technical testbed for new technologies such as IPv6

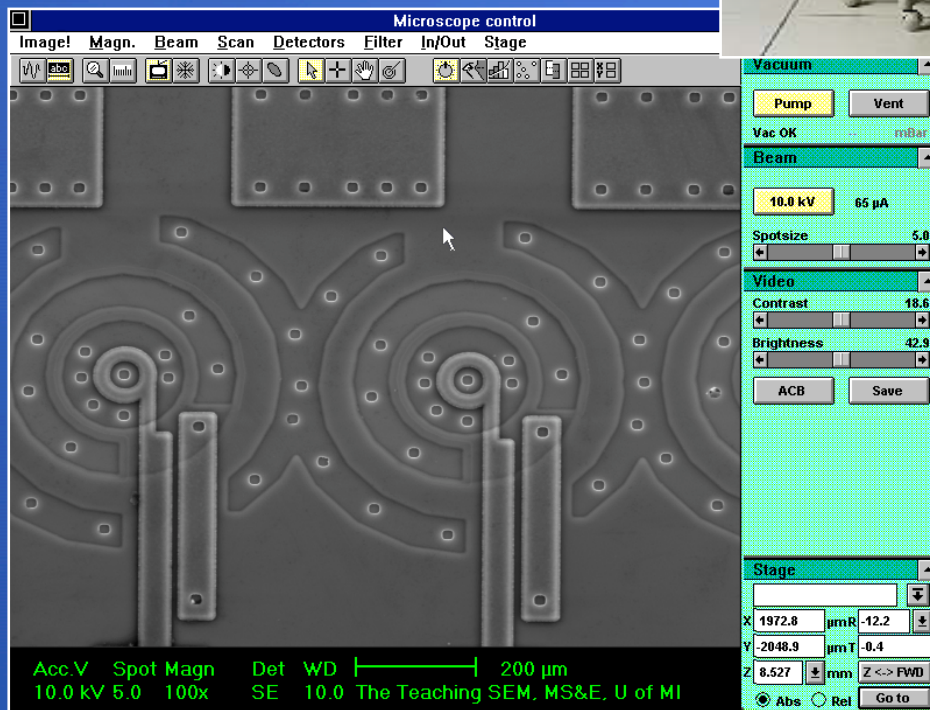
# How are NRENs organized and what do they do?

- Broad range of organizational models
  - Universities and other R&E institutions as members, not-for-profit organization
  - Funding models vary
    - Government-funded through Ministry of Higher Education, Science & Technology or ICT
    - Self-funded by member universities
  - See the TERENA Compendium for organizational detail on tens of NRENs
    - <http://www.terena.org/compendium>



Sharing scarce  
educational, research  
resources.

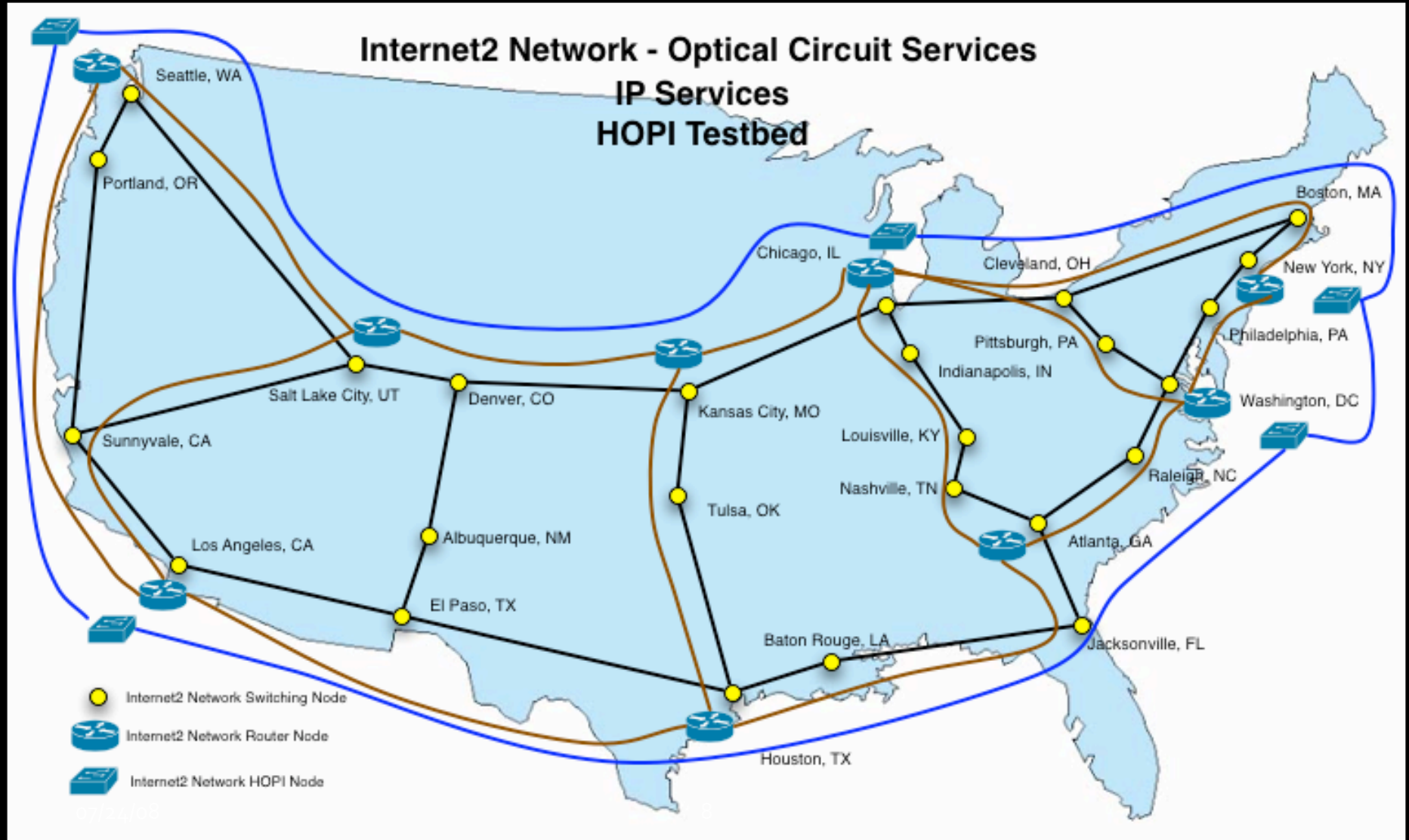
Access to scientific  
instruments for research,  
teaching and learning



Expensive resources can  
be shared between  
institutions, across  
distance

- Laboratory instruments
- Computers
- Databases
- Library materials





# I2 International Partner Program

- Forms partnerships between organizations with similar goals/objectives and similar constituencies – counterparts in other countries
- 50 partnership agreements - well over 50 NRENs
- Benefits
  - Provide access for users of the Internet2 Network to the Research and Education Networks of over 87 countries
  - Basis for understanding how to facilitate collaborations between US Internet2 community and counterparts in other countries
  - Basis for joint development activities with Internet2 counterparts in other countries



# INTERNATIONAL PARTNERSHIPS

## Europe

ARNES (Slovenia)  
BELNET (Belgium)  
CARNET (Croatia)  
CESnet (Czech Republic)  
DANTE (Europe)  
DFN-Verein (Germany)  
FCCN (Portugal)  
GARR (Italy)  
GIP-RENATER (France)  
GRNET (Greece)  
HEAnet (Ireland)  
HUNGARNET (Hungary)  
JISC, JANET (United Kingdom)  
NORDUnet (Nordic Countries)  
PSNC, PIONIER (Poland)  
RedIRIS (Spain)  
RESTENA (Luxemburg)  
RIPN (Russia)  
SANET (Slovakia)  
Stichting SURF (Netherlands)  
SWITCH (Switzerland)  
TERENA (Europe)

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## Sub-Saharan

### Africa

TENET (South Africa)

### Americas

CANARIE (Canada)  
CEDIA (Ecuador)  
CLARA (Latin America and Caribbean)  
CNTI (Venezuela)  
CR2Net (Costa Rica)  
CUDI (Mexico)  
INNOVA|RED (Argentina)  
REUNA (Chile)  
RNP [FAPESP] (Brazil)  
SENACYT (Panama)  
University of the West Indies (Caribbean)

### Middle East

Khalifa University of Science, Technology and Research (UAE)  
Israel-IUCC (Israel)  
MCIT [EUN, ENSTINET] (Egypt)  
Qatar Foundation (Qatar)

## Asia and Pacific Rim

AARNET (Australia)  
ANF (Korea)  
APAN (Asia - Pacic)  
CDAC, ERNET (India)  
CERNET, CSTNET, NSFCNET (China)  
JAIRC (Japan)  
JUCC (HongKong)  
MYREN, MDeC (Malaysia)  
NECTEC, UNINET (Thailand)  
PERN (Pakistan)  
REANNZ (New Zealand)  
SingAREN (Singapore)  
TANet2 (Taiwan)

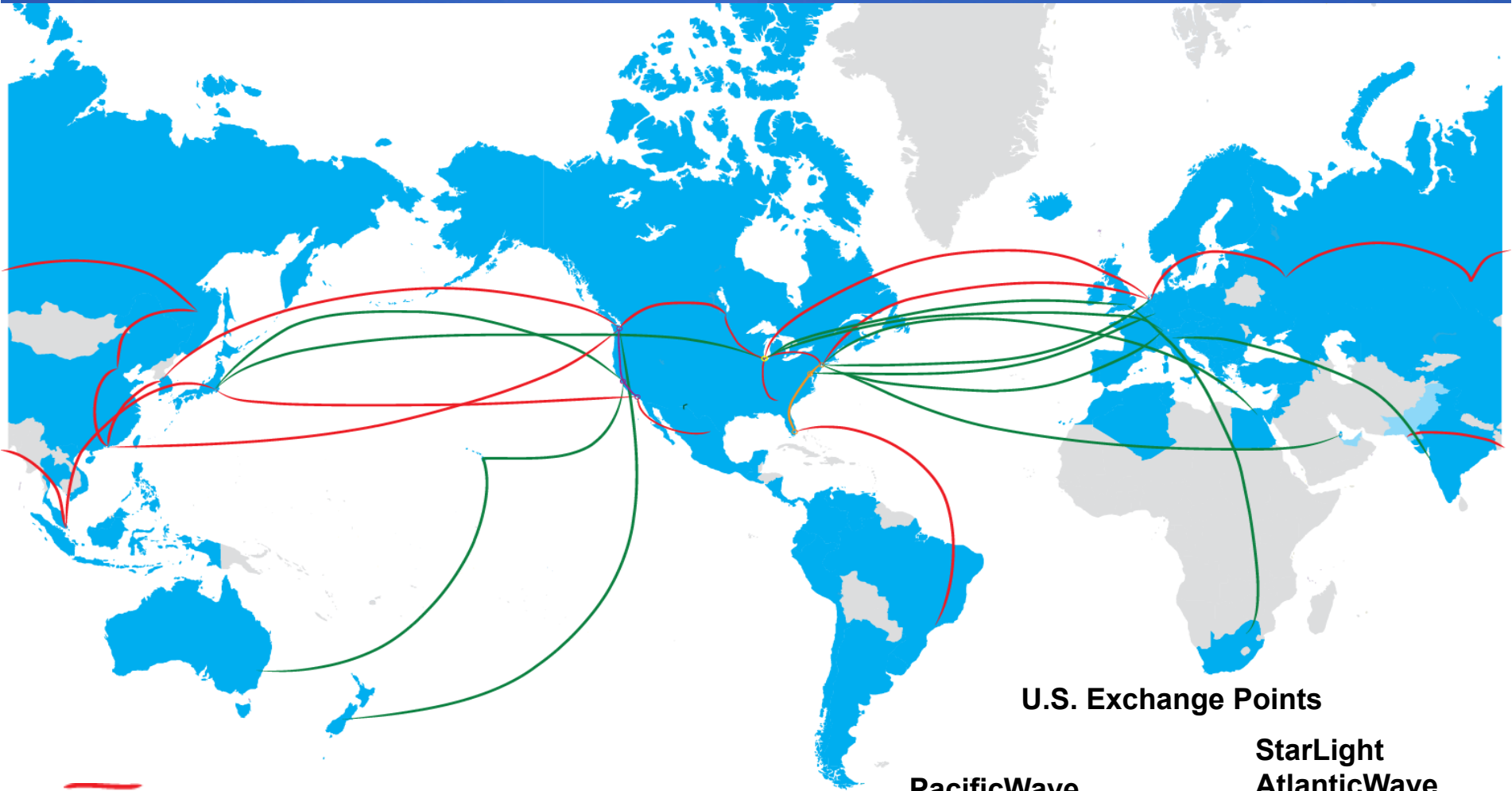
## Related

### Partnerships

APRU (Asia Pacic)  
IEEAF



# THE INTERNATIONAL REACH OF THE INTERNET2 NETWORK



### U.S. Exchange Points

- |                             |                     |
|-----------------------------|---------------------|
| <b>PacificWave</b>          | <b>StarLight</b>    |
| <b>PacificWave-North</b>    | <b>AtlanticWave</b> |
| <b>PacificWave-Bay Area</b> | <b>MANLAN</b>       |
| <b>PacificWave-South</b>    | <b>NGIX-East</b>    |
|                             | <b>AMPATH</b>       |



Other international connections

For further information regarding the international programs of Internet2, visit <http://international.internet2.edu>





# THE INTERNATIONAL REACH OF THE INTERNET<sub>2</sub>

## NETWORK

### AFRICA

Algeria (CERIST)  
Egypt (EUN/ENSTINET)  
Morocco (CNRST)  
South Africa (TENET)  
Tunisia (RFR)

### AMERICAS

Argentina (INNOVA|RED)  
Brazil (RNP2/ANSP)  
Canada (CA\*net)  
Chile (REUNA)  
Colombia (RENATA)  
Costa Rica (CR2Net)  
Ecuador (CEDIA)  
El Salvador (RAICES)  
Guatemala (RAGIE)  
Mexico (Red-CUDI)  
Panama (RedCyT)  
Peru (RAAP)  
Uruguay (RAU2)  
Venezuela (REACCIUN2)

### ASIA and PACIFIC

Australia (AARNET)  
China (CERNET, CSTNET,  
NSFCNET)  
Fiji (USP-SUVA)  
Hong Kong (HARNET)  
India (ERNET)  
Indonesia (ITB)  
Japan (SINET, WIDE, JGN2)  
Korea (KOREN, KREONET2)  
Malaysia (MYREN) <sup>06/09/08</sup>

### ASIA and PACIFIC cont'd

New Zealand (KAREN)  
Philippines (PREGINET)  
Russia (RBnet, RUNNET)  
Singapore (SingAREN)  
Taiwan (TANet2, ASNet)  
Thailand (UNINET, ThaiSARN)  
Vietnam (VINAREN)

### CENTRAL ASIA

Armenia (ARENA)  
Georgia (GRENA)  
Kazakhstan (KAZRENA)  
Tajikistan (TARENA)  
Uzbekistan (UZSCI)

### EUROPE and MIDDLE EAST

Albania (ASA/INIMA)  
Andorra (Univ. of Andorra)  
Austria (ACONet)  
Belgium (BELNET)  
Bosnia-Herzegovina (BIHARNET)  
Bulgaria (ISTF)  
Croatia (CARNet)  
Cyprus (CYNET)  
Czech Republic (CESNET)  
Denmark (Forskningsnettet)  
Estonia (EENet)  
Finland (Funet)  
France (Renater)  
Germany (G-WIN)  
Greece (GRNET)  
Hungary (HUNGARNET)  
Iceland (RHnet)

### EUROPE and MIDDLE EAST cont'd

Ireland (HEAnet)  
Israel (IUCC)  
Italy (GARR)  
Jordan (JUNET)  
Latvia (LATNET)  
Lithuania (LITNET)  
Luxembourg (RESTENA)  
Macedonia (MARNET)  
Malta (Univ. Malta)  
Netherlands (SURFnet)  
Norway (UNINETT)  
Palestinian Territories (Government  
Computing Center)  
Poland (PIONIER)  
Portugal (RCTS2)  
Qatar (Qatar FN)  
Romania (RoEduNet)  
Serbia-Montenegro (AMREJ, UoM/MREN)  
Slovakia (SANET)  
Slovenia (ARNES)  
Spain (redIRIS)  
Sweden (SUNET)  
Switzerland (SWITCH)  
Syria (HIAST)  
Ukraine (URAN)  
United Kingdom (JANET)  
Turkey (ULAKBYM)

### MULTINATIONAL NETWORKS

APAN  
GEANT2  
redCLARA



# Network evolution: Infrastructure

For Example:







# International Research & Education Network connections

- The NSF IRNC program provides network connections linking U.S. research networks with peer networks in other parts of the world to support science and engineering research and education applications
- NSF Awards:
  - TransPAC2 (U.S. - Japan and beyond)
  - GLORIAD (U.S. - China, Russia, Korea)
  - Translight/PacificWave (U.S. - Australia)
  - TransLight/StarLight (U.S. - Europe)
  - WHREN-LILA (U.S. - Latin America)
- The GLIF map shows links and networks that offer their bandwidth capacity for use by international research communities for applications-driven and computer-system experiments

● <http://www.glif.is>

# International Connectivity Pieces

1. US-based international exchange points
2. Circuits across oceans and northern, southern borders
3. Infrastructure within other countries, regions
  - Transit across partner networks

# The Commercial Internet?

- Access to the commercial Internet for education and research institutions is important
- National, Regional, Inter-regional RENs can pool demand, provide access to the commercial Internet at 'bulk buy' rates to better serve research and education mission and goals



Operated by the Center for  
Internet Augmented Research  
and Assessment (CIARA) at  
Florida International  
University  
Miami, FL U.S.A



**AMPATH™**  
INTERNATIONAL EXCHANGE POINT IN MIAMI

Julio Ibarra, AMPATH Principal Investigator  
and CIARA Exec. Director  
Heidi Alvarez, Director CIARA  
Chip Cox, AMPATH Chief Operating Officer



**FIU**

FLORIDA INTERNATIONAL UNIVERSITY  
*Miami's public research university*



research • collaboration • scholarship

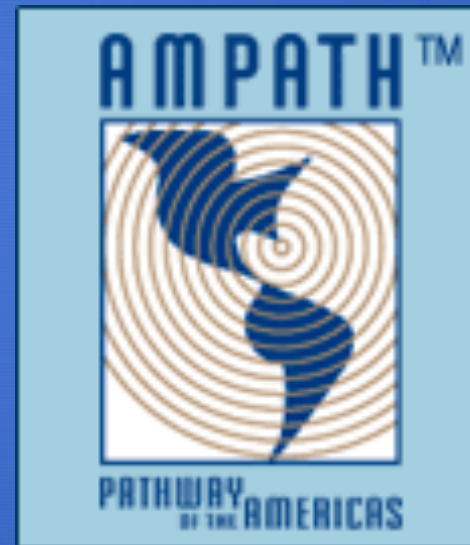
# OUTLINE

- AMPATH International Exchange Point
- AMPATH peering fabrics and connectors
- Projects at FIU served by AMPATH
  - WHREN-LILA
  - AtlanticWave
  - Global Cyber Bridges
  - CHEPREO

# AMPATH International Exchange Point

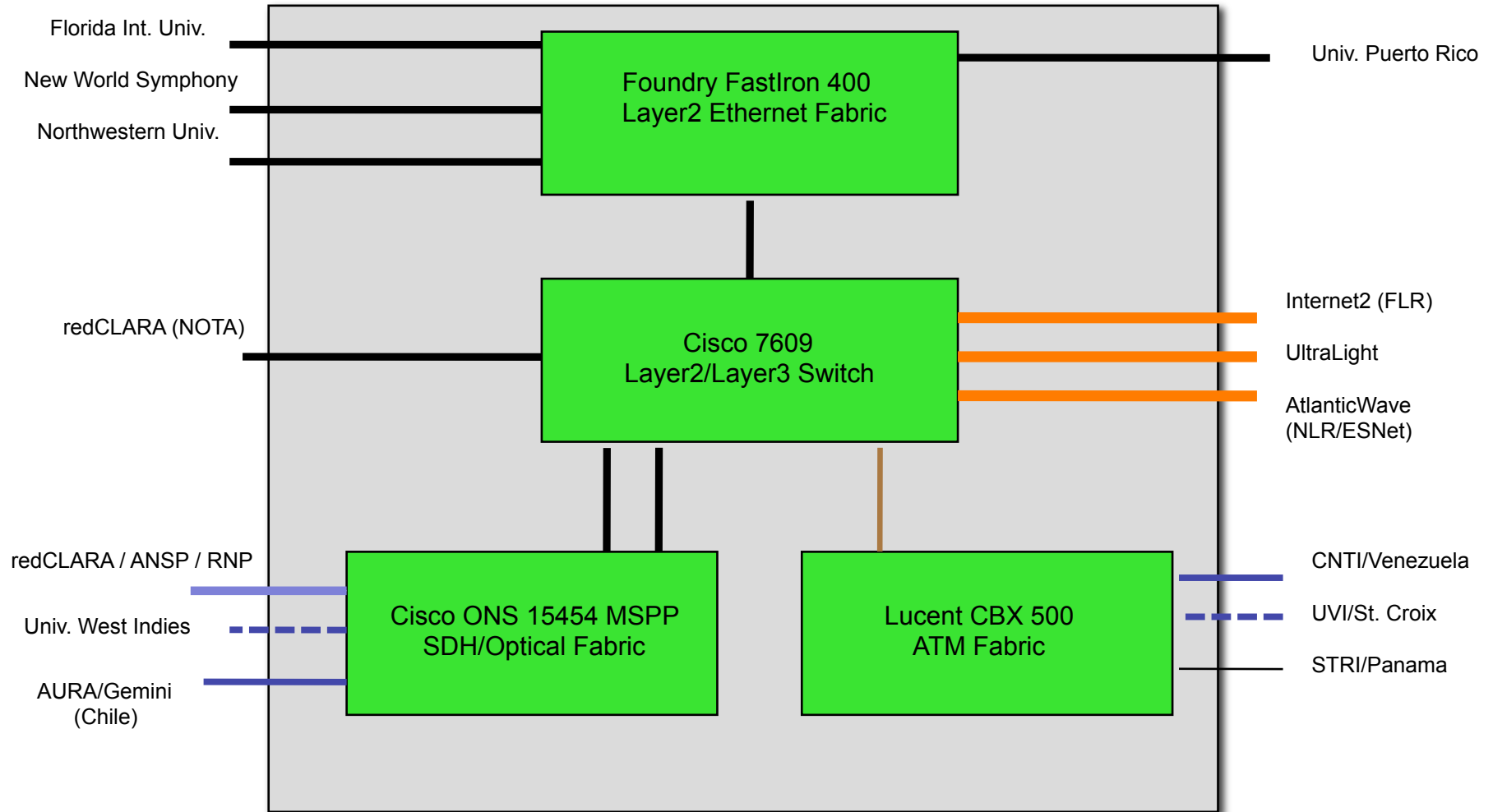
- Connectors are U.S. and international research and education networks
- Located at the NAP of the Americas in Miami
- Ethernet and ATM peering fabrics
- Connection types are
  - 100 Mbps, 1 Gbps and 10Gbps Ethernet
  - 45 Mbps, 155 Mbps and 622 Mbps ATM
  - 155 Mbps, 622 Mbps and 2.5 Gbps SDH
- Jumbo frame support
- IPv4/IPv6

- <http://www.ampath.net>





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INTERNATIONAL EXCHANGE POINT IN MIAMI



10 GigE    STM-16    GigE    OC-12    OC-3    DS-3



# WHREN-LILA



- **5-year NSF Cooperative Agreement**

- Florida International University (IRNC awardee)
- Corporation for Education Network Initiatives in California (CENIC)
- Project support from the Academic Network of Sao Paulo (award #2003/13708-0)
- CLARA, Latin America
- CUDI, Mexico
- RNP, Brazil
- REUNA, Chile



- **Links Interconnecting Latin America (LILA) aims to Improve connectivity in the Americas through the establishment of new inter-regional links**
- **Western-Hemisphere Research and Education Networks (WHREN) serves as a coordinating body whose aim is to leverage participants' network resources to foster collaborative research and advance education throughout the Western Hemisphere**





# WHREN-LILA



- 2.5Gbps circuit + dark fiber segment
- U.S. landings in Miami and San Diego
- Latin America landing in Sao Paulo, Tijuana and Miami
- Interregional links improve connectivity in the Americas
- Fosters collaborative research and advance education throughout the Western Hemisphere





AtlanticWave

NEW YORK WASHINGTON ATLANTA MIAMI SAO PAULO

- A-Wave is an integral component of the NSF IRNC WHREN-LILA project
- Creates an open distributed exchange and transport service along the Atlantic rim
- 10GigE Add/Drop in Miami, with extension to Sao Paulo



# Global Cyber Bridges



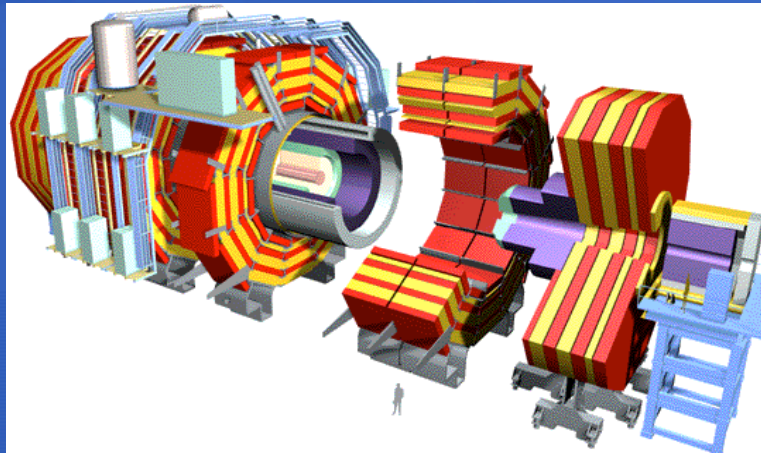
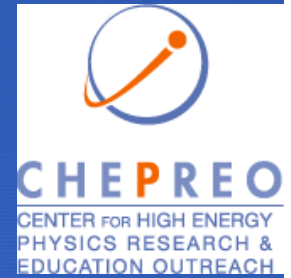
- NSF CI-TEAM Implementation Project, OCI-0636031
- Improve the technology training for a new generation of scientists
- Collaborators:
  - Computer Network Information Center of the Chinese Academy of Sciences, Beijing
  - City University of Hong Kong, China
  - University of Sao Paulo's School of the Future, Brazil
  - FIU in Miami, USA
- AMPATH provides Global CyberBridges fellows and faculty with connectivity to R&E computational grid resources at institutions and laboratories around the world



LambdaVision 100-Megapixel display and SAGE (Scalable Adaptive Graphics Environment) software developed by the Electronic Visualization Laboratory at the University of Illinois at Chicago. Major funding provided by NSF.



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



<http://www.chepreo.org>

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

- Supports Brazil's and South America's access to Tier2s and Tier1s in the U.S. and to CERN
- Collaboration with Florida State University (FSU), the University of Florida (UF), the California Institute of Technology (Caltech)
- Leverages IRNC WHREN-LILA infrastructure to support data-intensive science from High-Energy Physics and Astronomy communities
- Collaborations with Open Science Grid, GridUNESP, Kyatera, UltraLight and others to enable data intensive science in the western hemisphere

# Internet2 “Emerging NRENs” Interest Group

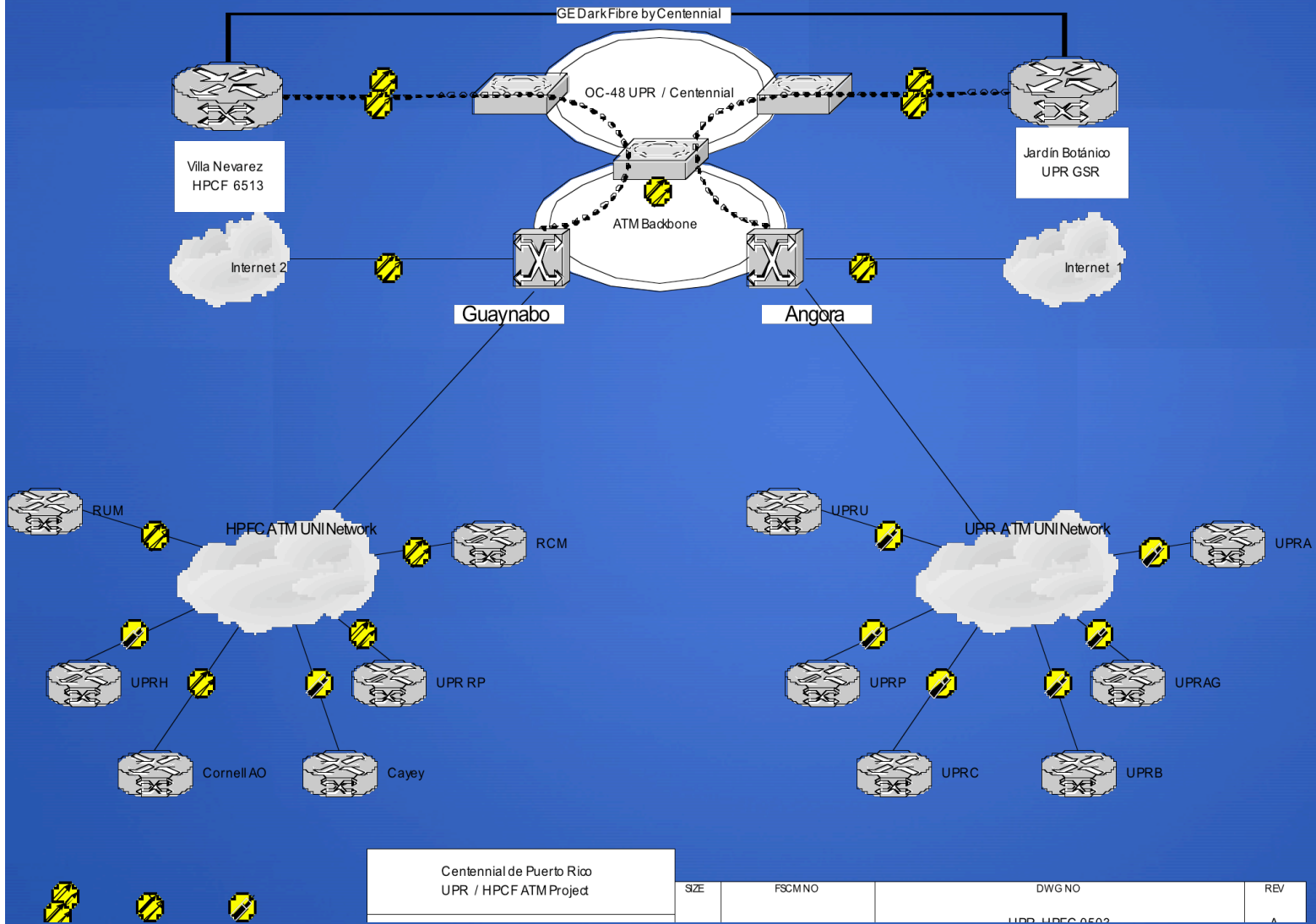
- Convenes Internet2 members and partners to focus on areas currently underserved by NRENs
- Awareness raising with key resource-providers
  - WorldBank, Inter American Development Bank, NSF, USAID, Dept of State
- Join CaribREN SIG and view the Wiki at [http://international.internet2.edu/intl\\_connect/carib\\_sig.html](http://international.internet2.edu/intl_connect/carib_sig.html)
- Next Meeting: October 13<sup>th</sup>, 2008 New Orleans
  - [www.internet2.edu](http://www.internet2.edu) for meeting registration

# About the Caribbean Research & Education Networking (CaribREN) Special Interest Group

- **Mission:** To advance the state of high-performance networking for research and education in the Caribbean.
- **Membership** is open to all institutions and individuals with an interest in supporting, contributing, or learning more about the mission of the CaribREN SIG.
- **Current membership** ranges from Caribbean interests, US and Latin American research & education networks, scientists, and educators.



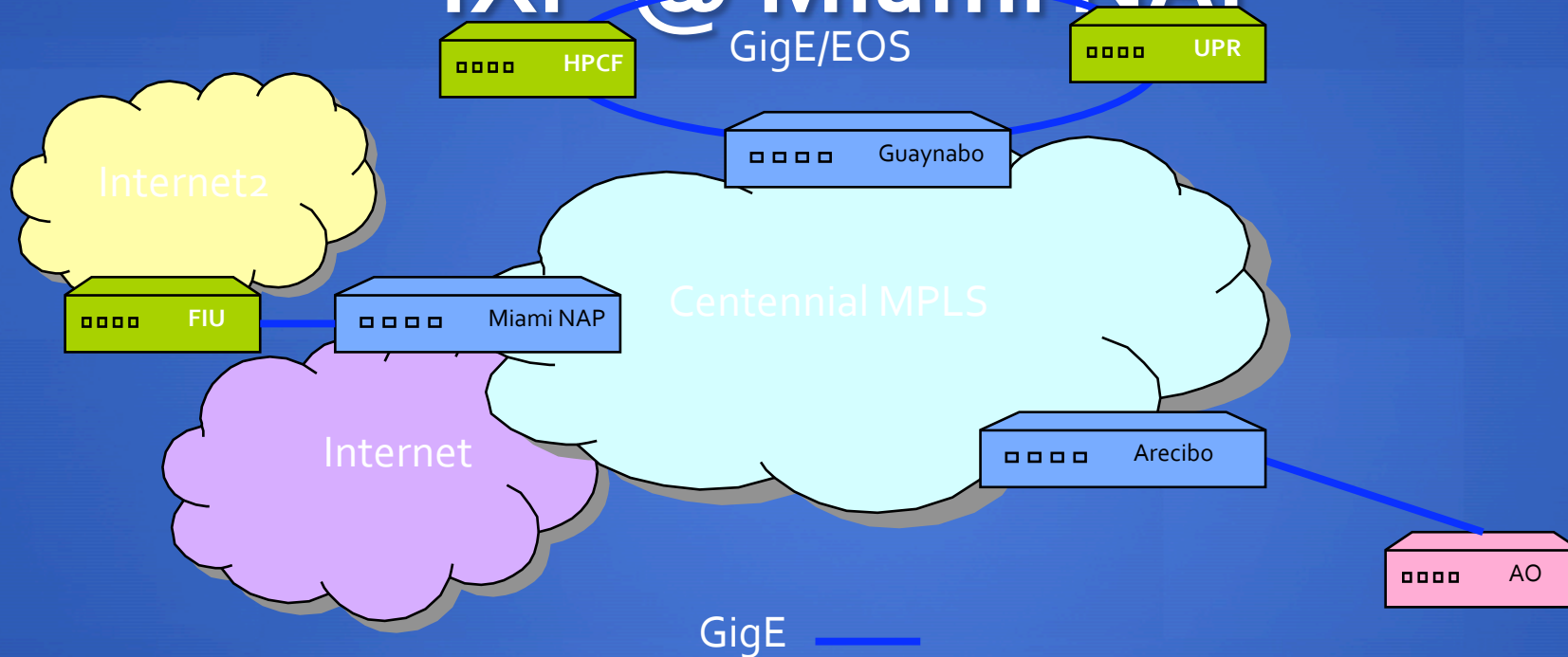
# University of Puerto Rico (UPR)



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# UPR GigE Solution to AMPATH

## IXP @ Miami NAP

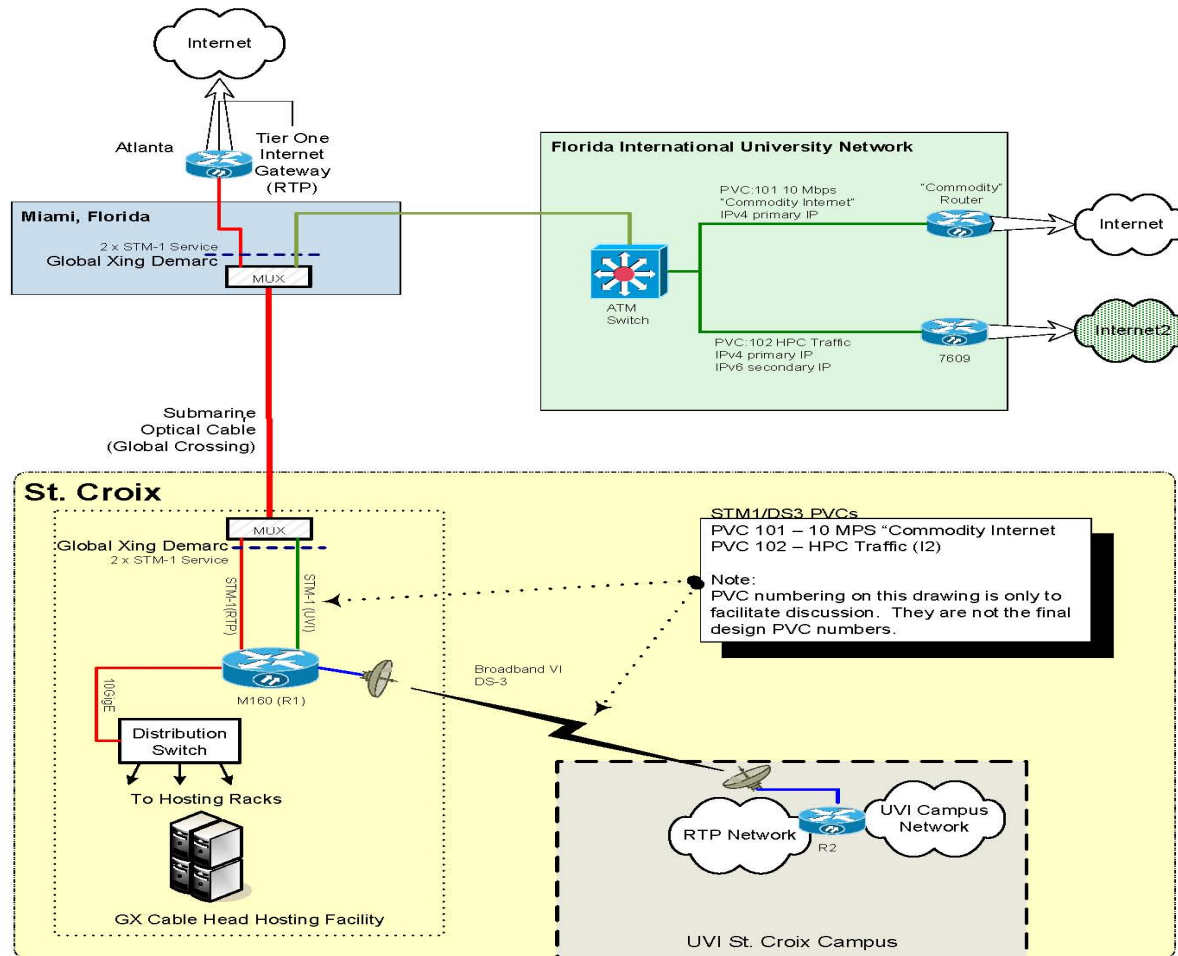





# University of the West Indies ICT Infrastructure

- Each main campus (Trinidad, Jamaica, Barbados) has...
  - Diverse fibre network connecting all buildings to each resp. campus back-bone
  - Mostly Cisco back-bone and edge devices
  - Campus-wide wireless coverage
  - Intercampus connectivity via leased circuits as well as Internet
- In 13 other Caricom countries
  - Fully equipped computer labs
  - Teaching centres



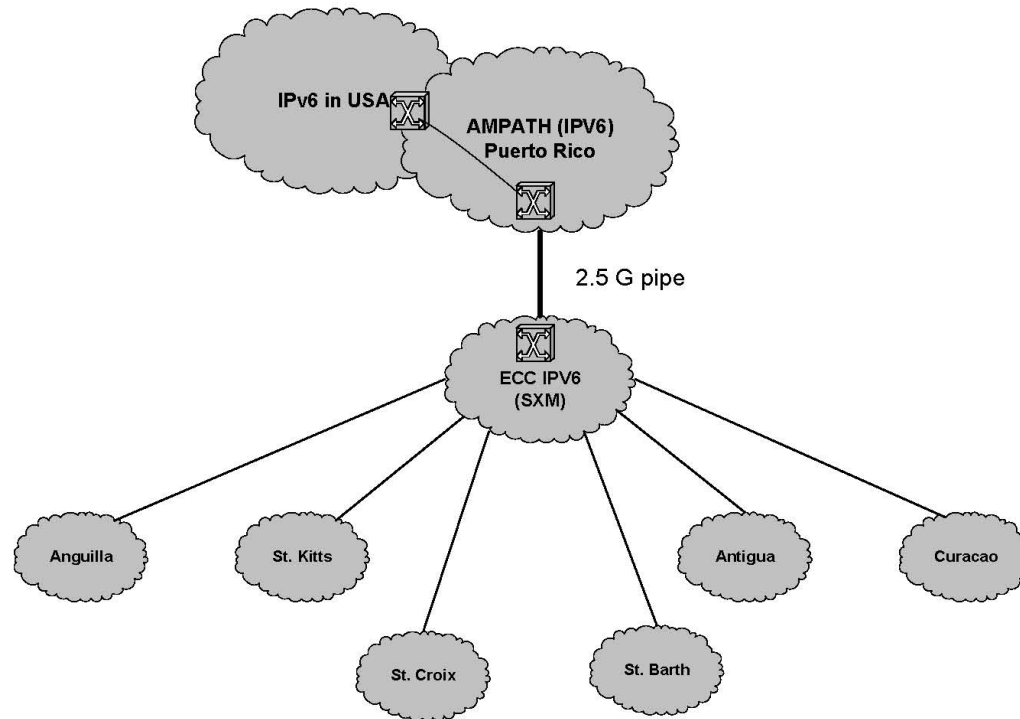
# University of the Virgin Islands



-  RTNet-owned multiplexer
-  Carrier or Provider-owned multiplexer
-  Connection to Internet2

**RTNet** Network Diagram  
 Initial Deployment  
 Revised: 26 July 2007  
 MZK Corporation

# Eastern Caribbean IPv6 Network



## **Eastern Caribbean IPv6 network**

This represent the ECC IPv6 network with St. Maarten (SMPR-1) as a hub connecting to the AMPATH (IPv6) network in Puerto Rico

## **ECC IPv6 Network**

Subject:	SMITCOMS as a hub of IPv6
By:	Smitcoms N.V.
Date:	April 12, 2006 - rev 1.

# Caribbean Knowledge and Learning Network (CKLN)

- Launched by the Caribbean Community (CARICOM) and the Organization of Eastern Caribbean States (OECS) in 2004, the Caribbean Knowledge and Learning Network (CKLN) is a multilateral project, supported by the OAS, the World Bank, the European Union and the Canadian International Development Agency (CIDA).
- The project is designed to enhance the competitiveness of Caribbean countries, using information and communication technologies to connect the Caribbean to the global pool of knowledge, developing human resources and facilitating greater regional integration
- CKLN will meet with the Caribbean R&E Networking Special Interest Group at the Fall 2008 Internet2 Members Meeting in New Orleans (October 12<sup>th</sup> – October 15<sup>th</sup> [www.internet2.edu](http://www.internet2.edu) )



# Applications

- Astronomy
- Bio-sciences
- High Energy and Nuclear Physics
- Earth observation, environment
- Health Sciences
- Veterinary Medicine
- Surgery and clinical care
- Humanities
- Arts Performance
- Distributed computation
- Virtual laboratories
- Digital libraries
- Distributed learning
- Interactive digital video and audio
- Remote instrument access and manipulation
- Tele-immersion

# Radio Astronomy, e-VLBI

- The e-VLBI community is using AtlanticWave for the Arecibo (Caribbean) and ROEN (Brazil) antennas to participate in data-intensive experiments
- Antennas communicate directly with correlation site
- Latency is lower than router-based networks



# Optical Astronomy International Collaboration

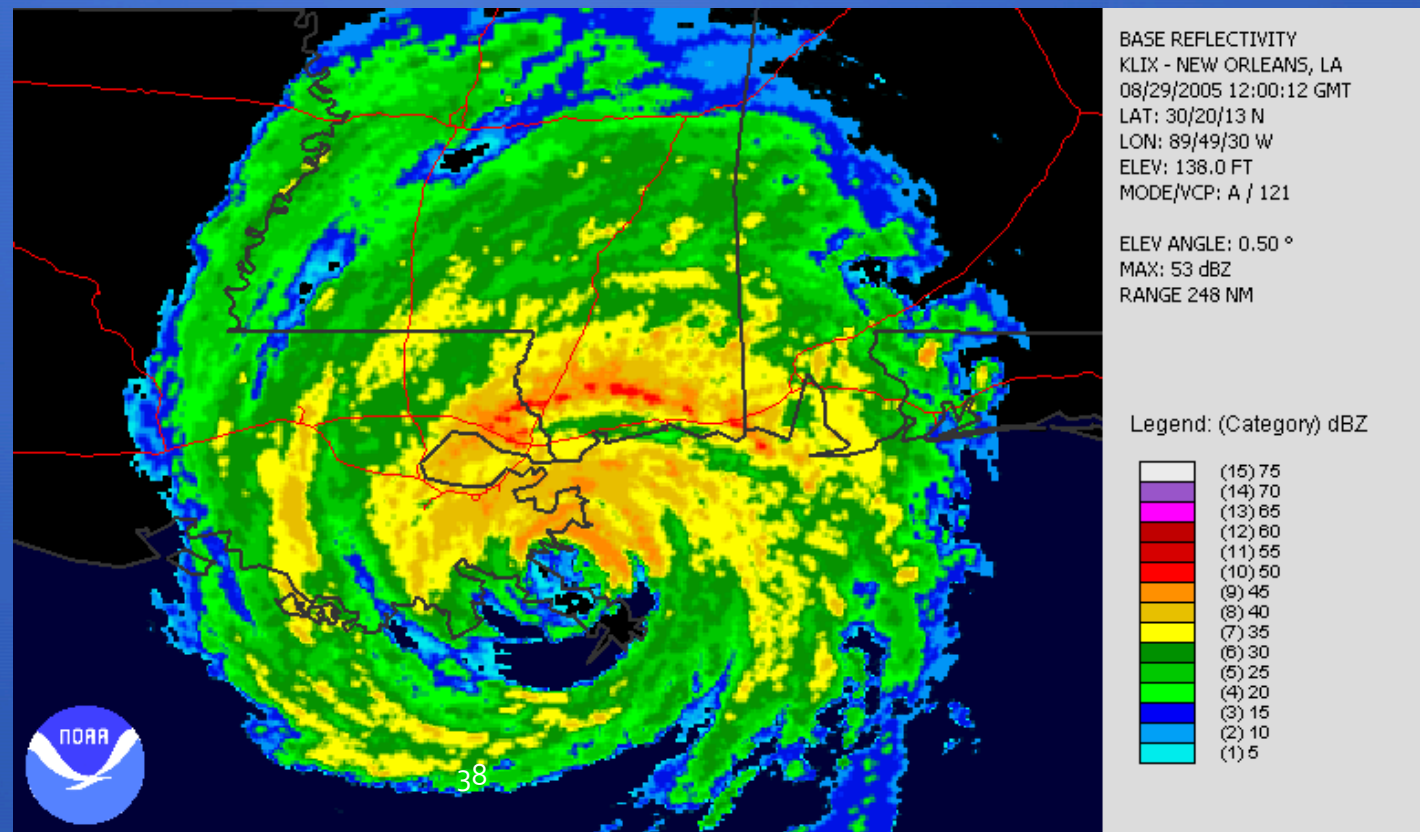




# IRADS: Integrated Radar Data Services

## University of Oklahoma – using NEXRAD Level II data

- 4 National Weather Services Regional Headquarters (RHQ) sites receive data from each of 140 Doppler radars
- Each RHQ server is linked to the Internetz's Abilene Network
- Data are transmitted directly to University of Oklahoma





# Music Master Classes

- Catering to the needs of musicians
  - High fidelity video and audio via MPEG2
  - Optimized for latency, audio/video synchronization
- Connecting Oklahoma with the New World Symphony in Miami, Florida
  - Removing physical distance as the reason why a student and instructor cannot interact



Showcases:

- Distance Teaching and Learning
- Video (and audio) as data
- Extending the reach of resources

## RESEARCH CENTERS IN MINORITY INSTITUTIONS Medical Sciences Campus

The project is supported by Grant Number G12RR03051(RCMI Program, University of Puerto Rico Medical Sciences Campus) from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NCRR or NIH.

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### Live Video Stream of Endoscopic Procedures from the University of Puerto Rico School of Medicine to the Johns Hopkins Hospital via Internet2

On November 13, 2007, the RCMI Center for Research Information Architecture transmitted a live video stream of endoscopic views from the Experimental Surgery Laboratory of the University of Puerto Rico School of Medicine to the Johns Hopkins Hospital. Video and audio were transmitted over IP via Internet2.



Dr. Priscilla Magno and Dr. Manuel Más at the laboratory.

<http://rcmi.rcm.upr.edu/rcminews/news0708/expsurg1107>

Slide courtesy of José G. Conde, MD, MPH

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## RESEARCH CENTERS IN MINORITY INSTITUTIONS Medical Sciences Campus

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### Transmission of Endoscopic Procedures Live to Medical Symposium in San Juan via Internet2



Dr. Takuji Gotoda explains a procedure from the Experimental Surgery Lab at the University of Puerto Rico School of Medicine

The RCMI Center for Information Architecture in Research collaborated with the Johns Hopkins Hospital and the Experimental Surgery Laboratory at the School of Medicine of the University of Puerto Rico (UPR) to transmit endoscopic procedures live from both institutions to the San Juan Intercontinental Hotel in San Juan, Puerto Rico. These activities were part of the symposium *Endoscopic Imaging and Therapies for Gastrointestinal Neoplasias: Today and Tomorrow* held on March 10th and 11th, 2008. This activity preceded the Viva la Vida 2008 Conference.

<http://rcmi.rcm.upr.edu/rcminews/news0708/vivalavidao8>

Slide courtesy of José G. Conde, MD, MPH

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# AMPATH Credits

- WHREN-LILA, AMPATH infrastructure, CHEPREO, Global CyberBridges, science application support, education, outreach and community building efforts are made possible by funding and support from:
- National Science Foundation (NSF) awards OCl-0441095, MPS-0312038, OISE-0549456, OCl-0537464, OCl 0636031, IIS 0646144, OISE 0715489, OCl 0734173, OISE 0742675
- Academic Network of Sao Paulo (award #2003/13708-0)
- Florida International University
- Latin American Research and Education community
- The many national and international collaborators



# Thank You!

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