AmLight ExP
Americas Lightpaths Express & Protect

AtlanticWave SDX
INTERNATIONAL DISTRIBUTED SOFTWARE-DEFINED EXCHANGE

National Science Foundation

International Research Network Connections
IRNC PI Meeting
Chicago, IL
May 15, 2016

Julio Ibarra, PI
Heidi Morgan, Co-PI
Donald Cox, Co-PI
Jeronimo Bezerra, Chief Network Engineer

U.S.-Latin America 100G Link

PRESS RELEASE
FOR IMMEDIATE RELEASE
Contact: Liz Boten, eboten@internet2.edu

Americas Lightpaths Express and Protect Activates First US – Latin America 100G Networking Link Enhancing Infrastructure for Research and Education

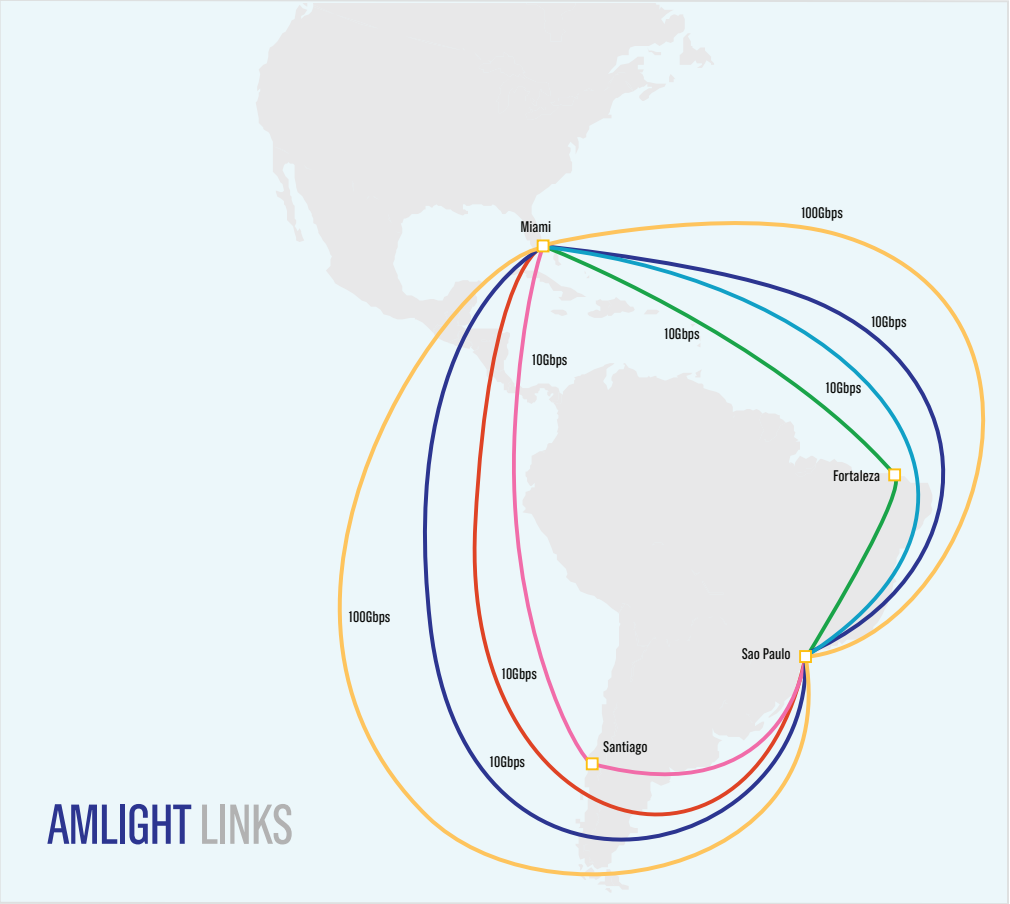
Miami, Florida, May 11, 2016 – Florida International University's Center for Internet Augmented Research and Assessment (CIARA) is pleased to announce the first 100G research and education network link between the U.S. and Latin America, a major component of the five-year AmLight ExP (IRNC BACKBONE: Americas Lightpaths Express and Protect) NSF Award#ACI-1451018.

On April 18, 2016 the AmLight Consortium activated the first 100G link of the AmLight-ExP project. It has 106ms delay and it goes via the Atlantic between Miami, FL and Sao Paulo, Brazil. The 100G link is under evaluation for the next 30 days. "To date, we have not seen any packet loss or errors and, to evaluate it, we are using an IXIA 100G packet generator," said Jeronimo Bezerra AmLight Chief Network Engineer.

The AmLight Consortium is a group of not-for-profit universities, state, national and regional research and education networks including the AmLight ExP project at Florida International University, RNP, ANSP, RedClara, REUNA, FLR, AURA, Latin American Nautilus, and Internet2.

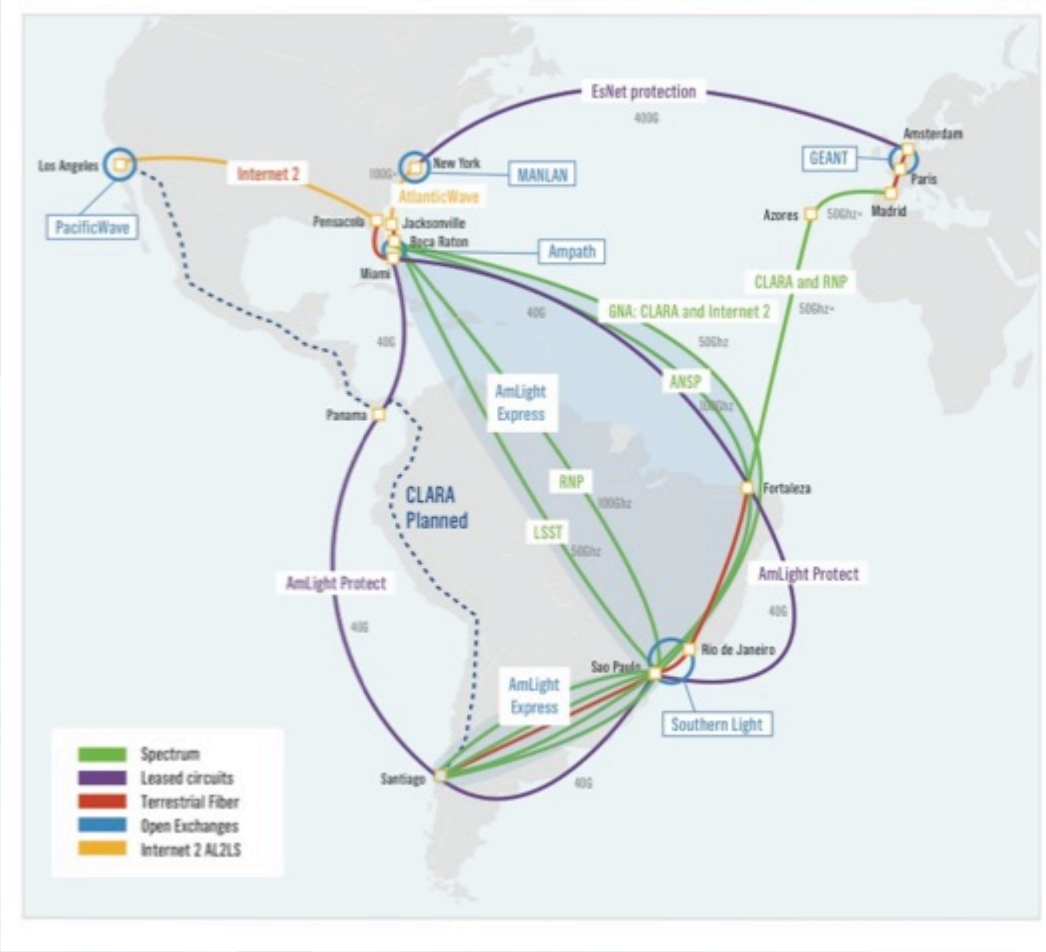
AmLight-ExP Today

- 100G Miami-São Paulo, Atlantic
- 100G Miami-São Paulo, Pacific, by early June
- 6x10G links, landings in São Paulo, Fortaleza, Santiago
- 160G of aggregate bandwidth capacity



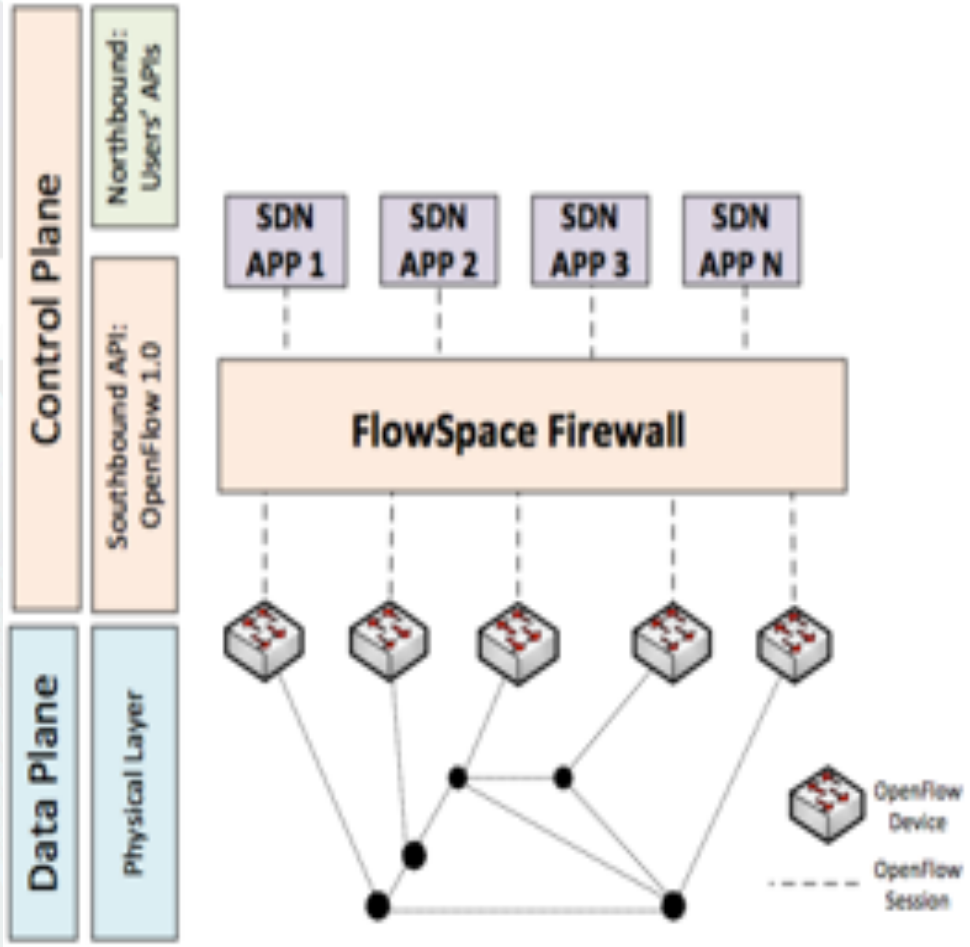
AmLight-ExP Future

- AmLight Express:
  - 300GHz of spectrum: Santiago-São Paulo, and São Paulo-Miami
  - Spectrum to be configurable by RENs to meet user/application requirements
- AmLight Protect:
  - 100G leased capacity ring
  - Miami, São Paulo, Santiago, Panama City, Miami
  - AMPATH, Southern Light, REUNA, and RedCLARA operated
- Fortaleza as a South Atlantic Crossroads
  - EulaLink submarine cable from Fortaleza to Portugal
  - SACS submarine cable to Angola (Q3 2018)
  - CBCS submarine cable to Cameroon (Q4 2017)



Network Virtualization and SDN Applications

- AmLight became an SDN network in 2014
- Researchers are using slicing to prototype network-aware applications
  - implementing testbeds with real network devices
  - validating their research in a production environment, and at scale.
- Slicing isolates production traffic from experimental network testbeds
  - FSFW acts as a proxy between the physical layer (represented by OpenFlow devices and links) and the control layer, represented by SDN applications



Innovations to Minimize Risks on SDN Networks

- Running experimental testbeds in a production network environment
  - involves potential risks and
  - increases the complexity of operation and troubleshooting processes
  - Risks result from code instability in the OpenFlow agents deployed on the network devices
- To lower the risks of unexpected downtime caused by experimental testbeds, three innovations were created at AmLight
  - The Validation process, the Testbed Sanitizer, and the OpenFlow Sniffer

Innovations to Minimize Risks on SDN Networks(2)

- Validation Process:
  - Focuses on identifying OpenFlow messages that could affect network resilience, evaluating their impact on the OpenFlow production devices
- Testbed Sanitizer:
  - Filters all undesired OpenFlow messages per network device's line card and per software version
- OpenFlow Sniffer:
  - No traditional tools sufficiently supported the OpenFlow 1.0 specification
  - Developed to improve the effectiveness of the troubleshooting processes at AmLight-ExP

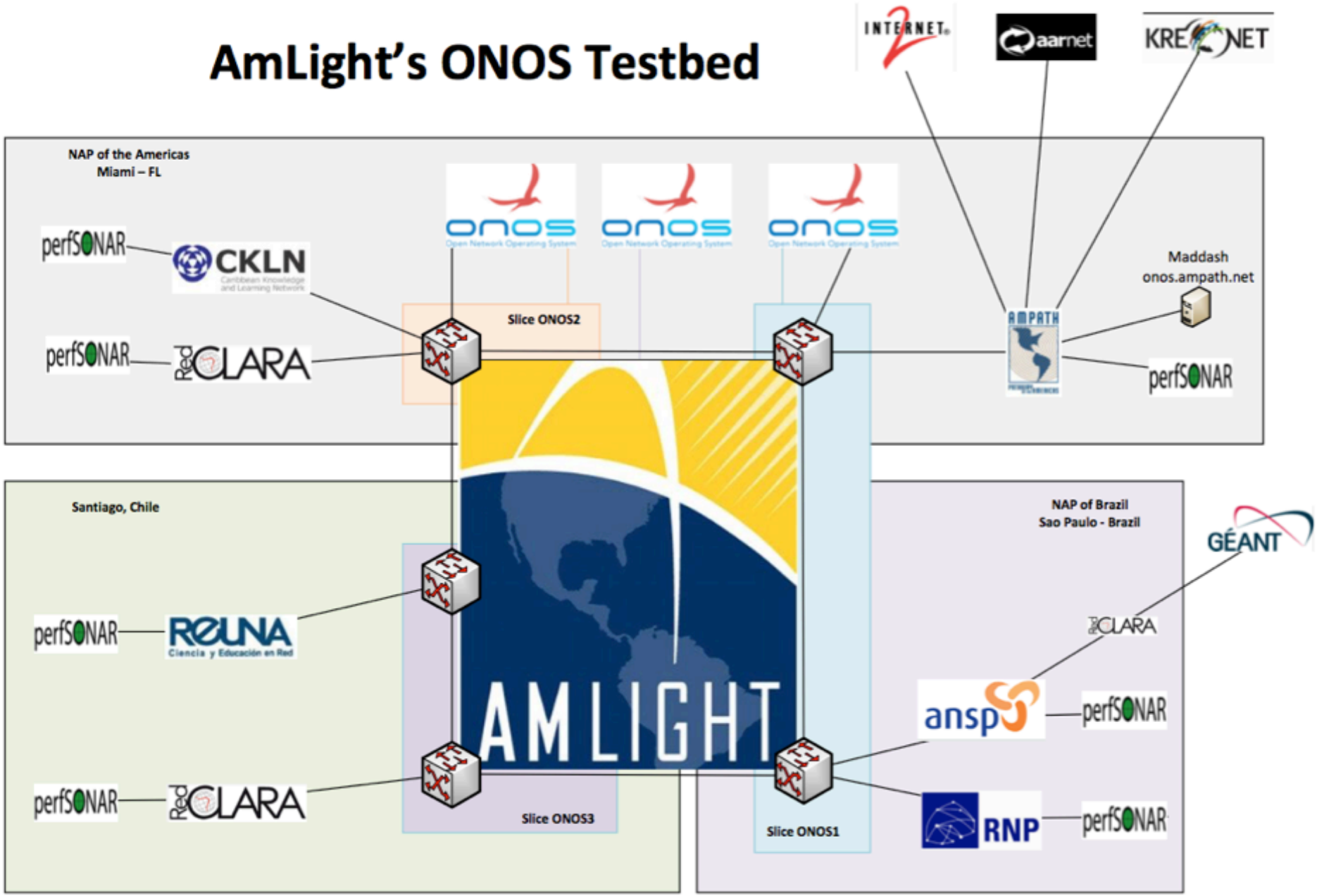
Experimental Testbeds on AmLight-ExP

- 6 network testbeds hosted at AmLight in parallel with production applications
- FIBRE Testbed
  - In partnership with RNP, a FIBRE (Future Internet testbeds / experimentation between BRazil and Europe) island was installed at AMPATH
  - AmLight was used to connect to other islands in Brazil.
  - Testbed built to
    - *Understand* what kind of requirements overlay SDN applications have and
    - *What* should be changed on production transport networks to support them

Experimental Testbeds on AmLight-ExP (2)

- ONOS SDN-IP Testbed
  - Handles BGP feeds, IP and IPv6 forwarding
  - Supports controller failover, improving resilience to SDN environments
  - A global SDN testbed without using legacy IP routers was created using OpenFlow 1.0
    - IPv6 will be supportted with OpenFlow 1.3
  - AmLight is now hosting ONOS in a production network environment
    - FIU, ANSP, RedClara, REUNA, RNP, CKLN, AARNET, GEANT/GTS, KREONET/Korea and NCTU/Taiwan are connected to the AmLight ONOS testbed

AmLight's ONOS Testbed



AmLight-ExP Year 2 Goals

- Deploy OpenFlow 1.3+ on AmLight links
- Connect Santiago and Fortaleza to 100G ring
- Prepare designs and documentation for spectrum
  - AmLight engineers will explore optical solutions that will handle the submarine and the metro part of the optical transport.
- Facilitate peering globally using ONOS SDN-IP
- Transition to the IRNC Advanced Measurement Instrument and Service (AMIS)
  - AMIS expands the capabilities of passive monitoring on SDN-enabled links
  - Collaborating with Prof. Yan Luo, AMIS PI
- Continue enhancing support for experimental testbeds
  - Supporting CENTRA testbeds on AmLight
    - Collaborations to Enable Transnational Cyberinfrastructure Applications (CENTRA)
    - Refers to a partnership and evolving framework for collaborations amongst research centers, institutes and laboratories across the world
    - In year 2, AmLight-ExP will explore the feasibility of supporting experimental testbeds in CENTRA
    - CENTRA research challenges and applications are global in nature: Environmental and biodiversity research; Disaster Management; Smart Cities; Visualization; Experimental Testbeds.

AmLight ExP
Americas Lightpaths Express & Protect

AtlanticWave SDX
INTERNATIONAL DISTRIBUTED SOFTWARE-DEFINED EXCHANGE

NSF Award ACI-1451024

International Research Network Connections Program

IRNC-RXP:

AtlanticWave-Software Defined Exchange:

A Distributed Intercontinental Experimental Software Defined Exchange (SDX)

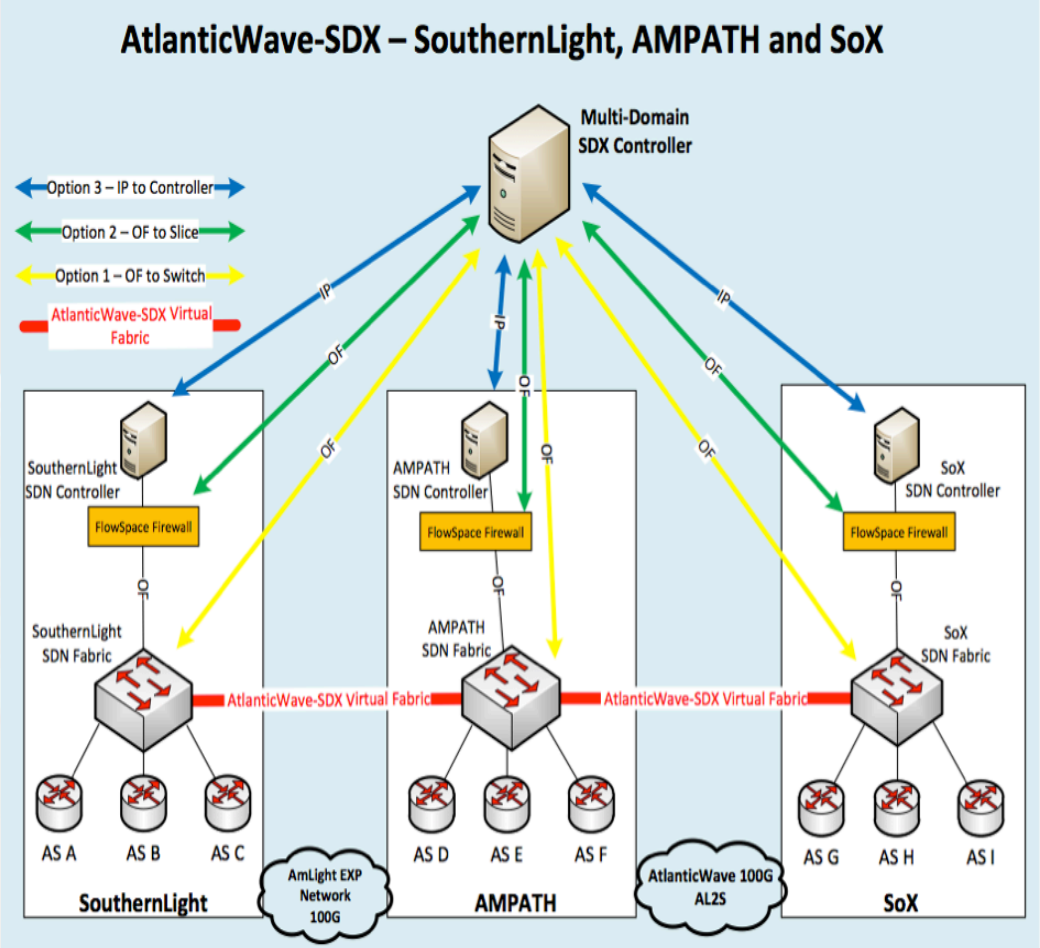
Julio Ibarra, PI
Russ Clark, Co-PI
Heidi Morgan, Co-PI
Jeronimo Bezerra, Network Engineer
Cas D'Angelo, Network Engineer
Sean Donovan, DevOps

AtlanticWave-SDX Project

- AtlanticWave-SDX (Awave-SDX) is building a distributed intercontinental experimental SDX in response to a growing demand to:
  - Support end-to-end services capable of
    - Spanning multiple SDN domains
    - Dynamic provisioning of end-to-end L2 circuits
    - Providing network programmability
  - Provide more intelligent network services to
    - Foster innovation
    - Increase network efficiency
- Florida International University (FIU) and Georgia Institute of Technology (GT) are implementing AtlanticWave-SDX, in collaboration with other exchange points supporting SDN

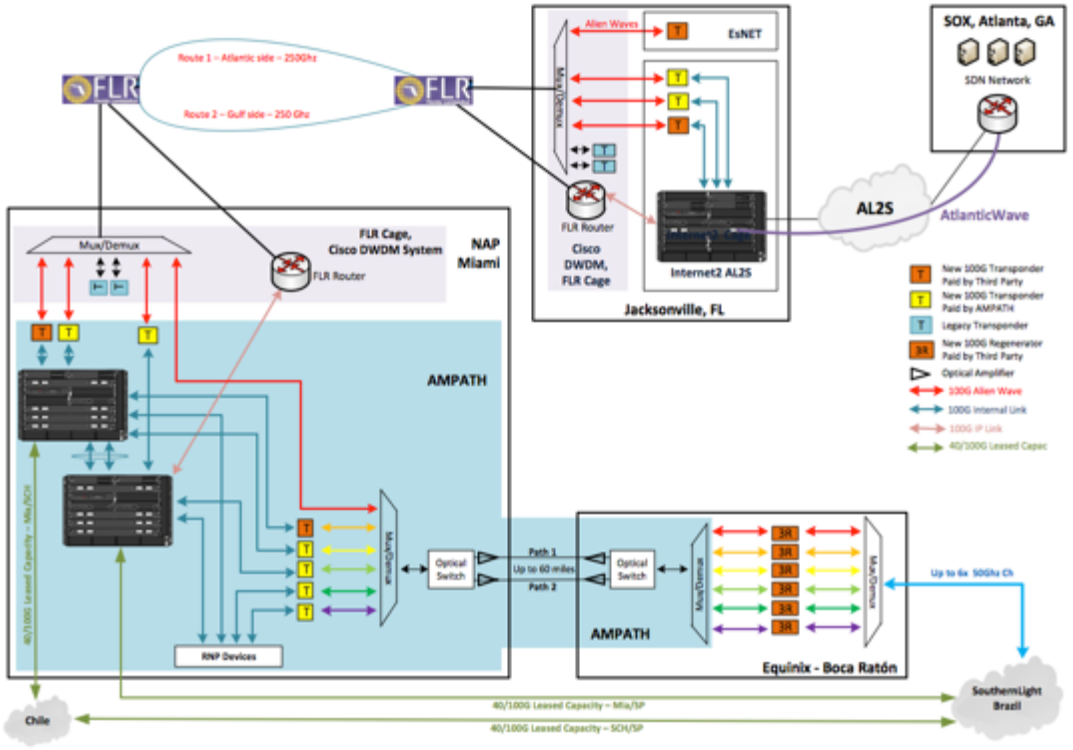
AtlanticWave-SDX Design

- Extending SDX concept to a multi-domain SDX across 3 exchange points
- Option 1 (yellow): Single SDX controller that manages the IXP switch fabric.
- Option 2 (green): Intermediate slice manager (FlowVisor or FSFW)
  - Individual controllers assigned a slice of network resources to be managed.
  - Achieves resource isolation
- Option 3 (blue): Creates a hierarchy of controllers.
  - Local controller at each XP managed by a higher level controller
- SDX Virtual Fabric refers to a slice (a set of network headers) that will define the forwarding behavior between all the exchange points



Network Infrastructure Design

- Years 1 and 2:
  - Upgrade AMPATH IXP infrastructure to support 140G in year 1
  - Deploy new technologies at AMPATH to fully support SDN in its switching fabric
- Years 3, 4 and 5:
  - Upgrade the switching capacity at AMPATH to receive 6 100G links from AmLight ExP
  - Extend capacity to Jacksonville over the FLR network to the Internet2 AL2S
  - FLR providing two sets of 250GHz channels in its backbone, provisioned over diverse paths



Supporting SDN applications

- Developing a software toolkit with APIs
- Application developers will be able to introduce demands to the controller
  - What resources, at what times, and with what performance requirements
- The Controller will then plan/schedule the use of resources
  - With prior knowledge of “what” and “when”
- SDX Controller Design Description and SDX specification documents have been written
- A prototype of the AtlanticWave-SDX controller is expected by Q4 2016 (I2 TechEx)

Supporting SDN Applications (2)

- Types of applications AtlanticWave-SDX will support:
  - Application-specific peering
    - Two neighbor AS exchange traffic only for certain applications
  - Inbound traffic engineering
    - AS can control inbound traffic on source IP or port number
  - Wide-area load balancing
    - Content provider can improve efficiency for client requests
  - Redirection through middle boxes
    - Redirecting targeted subsets of traffic (eg., suspected DoS traffic) through middle boxes (eg., firewall, load balancer, NAT)
  - On-demand virtual circuit provisioning
    - Provisioning virtual circuits on demand; eg., I2 AL2S, or Esnet OSCARS
  - Bandwidth Calendaring
    - Reserving bandwidth, scheduled for particular times, for an application

Science Driver: LSST

- Large-aperture wide-field ground-based 8.4 meter optical telescope
- Will take 6.4GB image every 17 seconds
- Network must transport images to NCSA within 5 seconds
- LSST operation will be composed to 2 channels:
  - A control channel and a data channel
  - Control channel handles remote operation of the telescopes by NOAO in Tucson, AZ
    - Control channel must be secure, with low latency, high priority and low bandwidth
  - Data channel will transmit 6.4GB images within 5 seconds
    - Data Channel requires high bandwidth availability, low latency and high priority
    - Support bursts close to 90G

LSST Applications and SDX

- Applications using Control Channel
  - Provision on-demand multi-domain virtual circuits with
    - Low latency, encryption, high priority and low bandwidth requirements
- Applications using Data Channel
  - Provision on-demand multi-domain virtual circuits with
    - High bandwidth availability, low latency and high priority
  - SDX reserves bandwidth for LSST to schedule image transfers

"AtlanticWave-SDX: An International SDX to Support Science Data Applications." Joaquín Chung, Jacob Cox, Julio Ibarra, Jerônimo Bezerra, Heidi Morgan, Russell Clark, Henry Owen. Supercomputing'15. November 2015

AtlanticWave-SDX Year2 goals

- Prototype the SDX Controller application
  - AMPATH and SoX, then SouthernLight
  - Test multi-domain functionality
- API for the SDX controller shall be made available to science communities
- Upgrade the switching fabric at AMPATH to support multiple 100G connections
- At SoX, augment core network infrastructure with OpenFlow 1.3 core switch
  - OpenFlow 1.3 is a requirement for the SDX Controller application
  - Coordinating with Internet2 and Esnet on the selection of a switch that sufficiently support OF 1.3 features for SDX

Extending fiber to McMurdo Station

- Chilean government is undertaking a new project to extend fiber to the bottom of Patagonia
- Extend fiber to McMurdo station through a new 4800km submarine cable
- Same distance (albeit different environment) to Miami-Fortaleza Brazil.
- If such a cable is possible, McMurdo and other stations could have the same connectivity to the world as any tier 1 university