AmLight ExP
Americas Lightpaths Express & Protect

AtlanticWave SDX
INTERNATIONAL DISTRIBUTED SOFTWARE-DEFINED EXCHANGE

IRNC Kickoff Meeting

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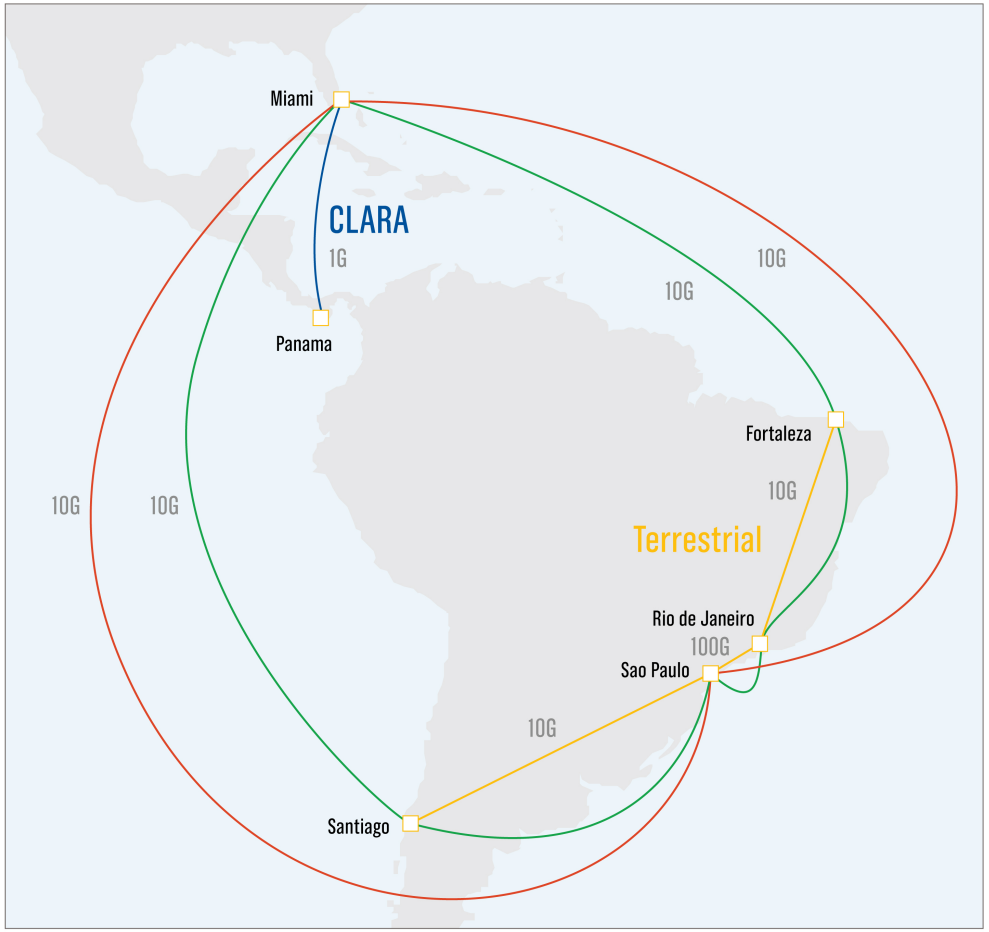
Outline

- Backbone: AmLight Express and Protect (ExP)
- RXP: AtlanticWave-SDX

AmLight Today

- 4 x 10G links
  - Two topologies and
  - Two submarine cable systems to increase resilience and support for experimentation
- SDN Ring: Miami-São Paulo, São Paulo-Santiago, Santiago-Miami
  - 20G total capacity
  - Full Openflow 1.0 and network virtualization support
  - Uses Brocade devices
- MPLS Ring: Miami-Fortaleza, Fortaleza-Rio, Rio-São Paulo, São Paulo-Miami
  - 20G total capacity
  - Layer2 support via L2VPN
  - Uses Juniper devices
- Mutual redundancy between SDN and MPLS rings



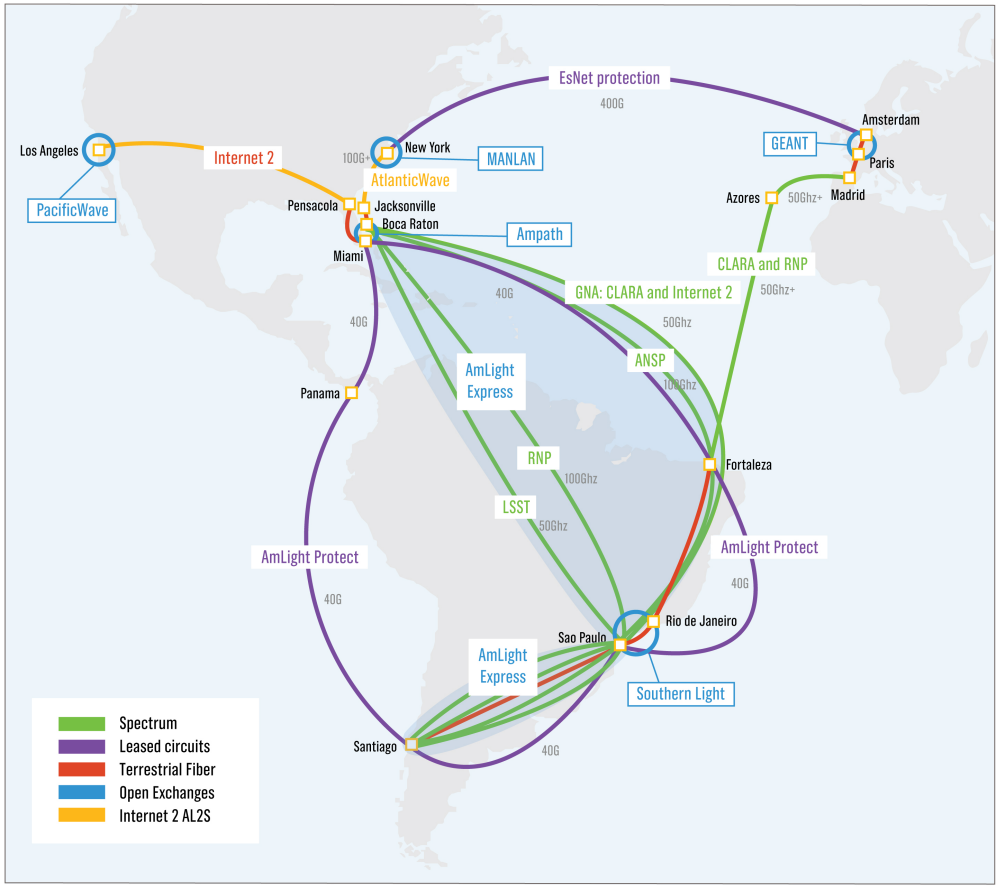
AmLight 2015-2017

- OpenWave 100G alien wave
  - U.S., Brazil, Latin America
  - Experimentation is initial focus
  - In the AmLight SDN domain
  - What we learn will enable our next 20 years
- 100G to AL2S, Miami-Jacksonville is operational
- 140G aggregate capacity using spectrum and leased circuits

AmLight Express and Protect (ExP) 2018-2031

- 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:
  - 40G leased capacity ring
  - Miami, São Paulo, Santiago, Panama City, Miami
  - AMPATH, Southern Light, REUNA, and RedCLARA operated
- Potential for unprecedented regional resilience for U.S.-Latin America, and U.S.-Europe connectivity, supporting global science research

680G+



2018-2031

AmLight ExP Challenges

- Bandwidth capacity into the U.S. on I2, ESnet and regionals
  - 680G+ capacity into the U.S.
- How to make the best use of spectrum to meet the network services requirements of LSST and other science drivers
  - Guidance and lessons learned form OpenWave
- Quality of Service
  - Bandwidth Guarantee in an OpenFlow/SDN network
  - Dynamic application load-balancing
- Security
  - Secure access with network virtualization
  - Isolation between applications
- Networking
  - Multipath TCP
  - Scalability
  - IP/IPv6/Multicast Routinng
  - Inter-SDN domain forwarding (SDX)

AtlanticWave-SDX Project

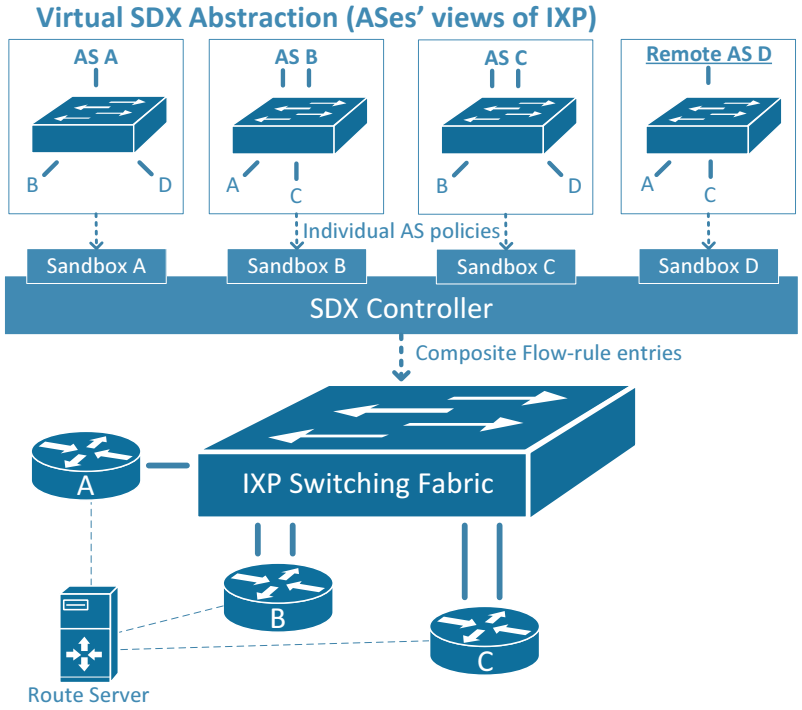
- AtlanticWave-SDX (Awave-SDX) is building a distributed intercontinental experimental SDX in response to a growing demand to:
  - Support end-to-end services
    - Capable of spanning multiple SDN domains
    - Dynamic provisioning of end-to-end L2 circuits
    - Network programmability
  - Provide 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

Conceptual Design

- AtlanticWave-SDX conceptual design is comprised of two components:
  - A Network Infrastructure Development Component
    - Bridges 100G of network capacity between the R&E backbone networks in the U.S. and S. America
  - An Innovation Component
    - Builds a distributed intercontinental experimental SDX between the U.S. and South America
    - Leverages open exchange point resources at SoX (Atlanta), AMPATH (Miami), and Southern Light (São Paulo, Brazil)

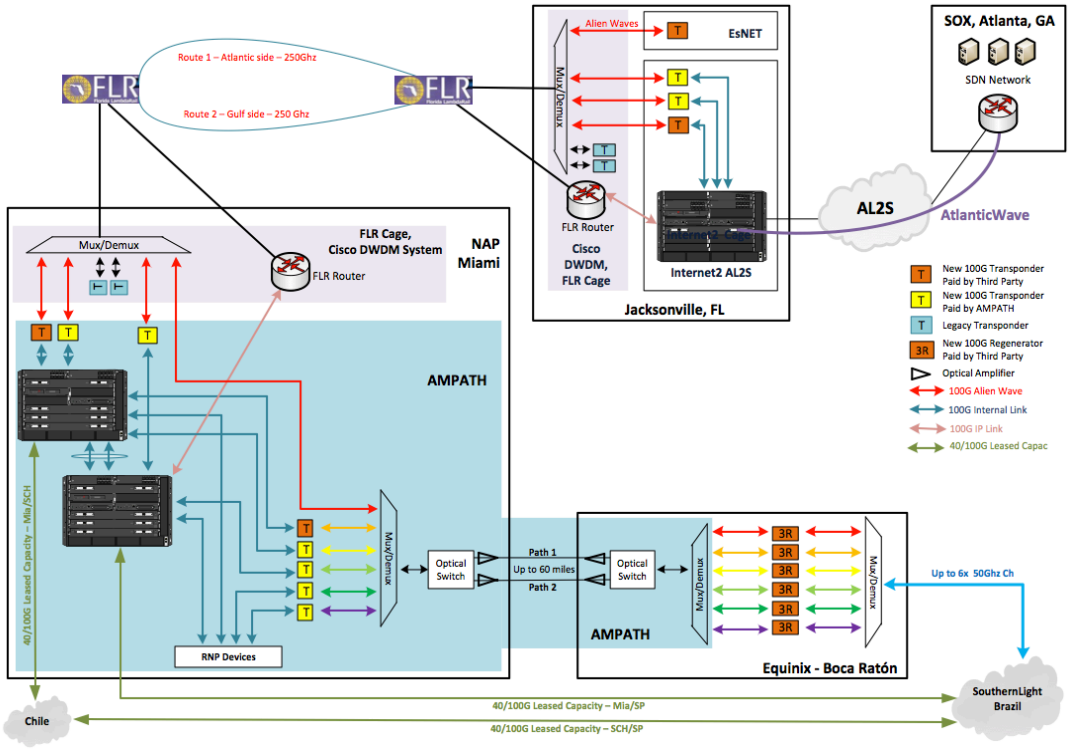
Virtual SDX Abstraction

- In a traditional IXP
  - Each participating AS connects a BGP speaking border router to a shared layer2 network, and
  - A BGP route server
- In an SDX
  - Each AS can run SDN applications that specify policies
  - The SDX combines the policies of multiple ASes into a single coherent policy for the physical switches
  - The SDX controller gives each AS the illusion of its own virtual SDN switch connecting its border router to each of its peer ASes
- The Virtual SDX concept is important for both:
  - Scaling the SDX architecture, and
  - Providing end users (or their application developers) with direct control over their own traffic throughout the network



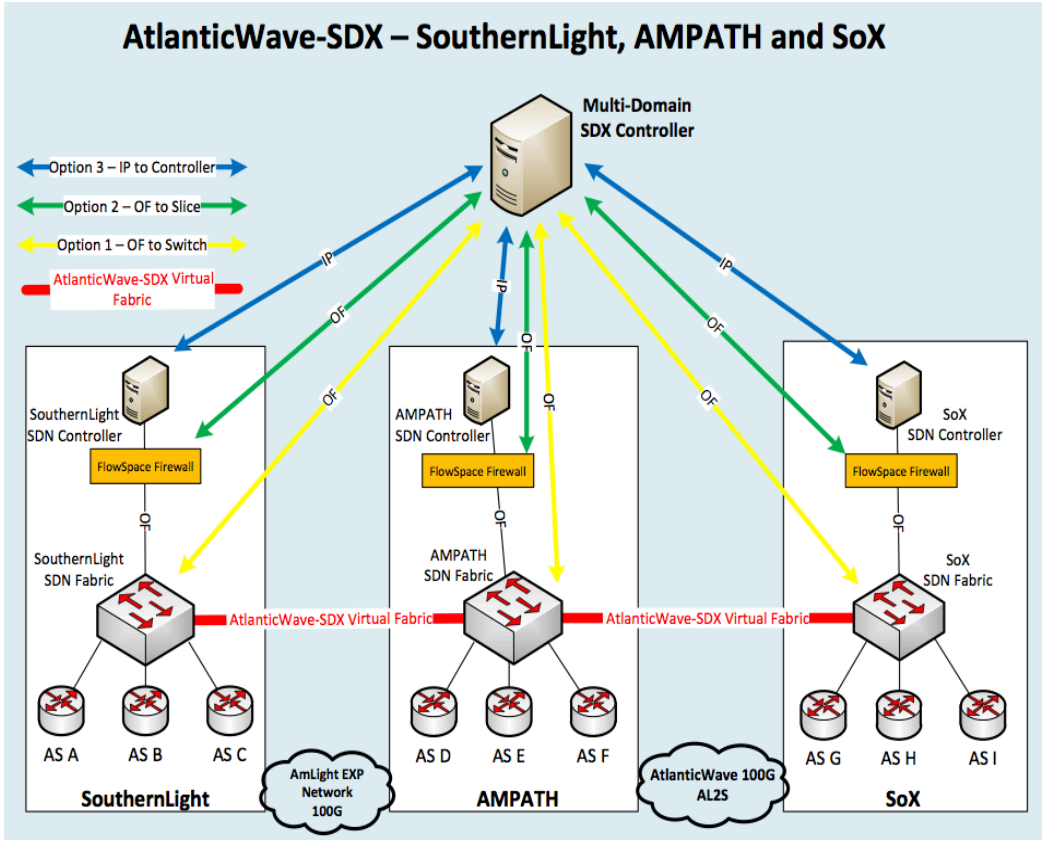
Network Infrastructure Development Component

- 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 will provide two sets of 250GHz channels in its backbone, provisioned over diverse paths



Innovation Component

- Three options of deployment for SDX:
  - Option 1:
    - Single SDX controller managing entire IXP switch fabric
  - Option 2:
    - Intermediate slice manager
      - allows individual controllers to be handed a slice of network resources
      - While isolating resources from others
      - Most practical approach in near term
  - Option 3:
    - Creates a hierarchy of controllers with a local controller at each IXP managed by a separate higher-level controller



Science Drivers

- Large Synoptic Survey Telescope (LSST)
  - Image transfer south-to-north for transient alert processing
  - Data Release Catalog
  - Control Information
  - Calibration Information
  - User access of scientific data in the Data Access Centers
- Atacama Large Millimeter Array (ALMA)
- U.S. Astronomy Observatories in Chile
  - CTIO, Gemini-South, SOAR, others
  - Dark Energy Camera (DECam)
- LHC Open Network Environment (LHCONE)
  - HEP experiments are moving towards more dynamic workflows and data management,
  - Significant increases in utilization of network resources in an active way
- Ultra-High Definition (UHD) Video
  - 4K UHD (8.3M pixels) and 8K UHD (33.2 Mpixels)
  - Minimum bandwidth requirement of 300Mbps with low packet loss and low jitter rates

AtlanticWave-SDX Challenges

- Executing AtlanticWave SDX for Boca and Miami Locations, over all switch / optical infrastructure
- Environment for researchers and practitioners to collaborate at-scale
  - Retaining graduate students for development of SDX
  - Prototyping for SDN applications and services
  - Scientific instruments on demand
  - Application specific infrastructure on demand
- SDX is a virtualized service
  - A dedicated slice on AL2S and AmLight
  - Create a multi-domain high-capacity distributed exchange point interconnecting AtlanticWave RXPs:
    - MANLAN, MAX GigaPoP, WIX, SoX, AMPATH, Southern Light
- Increase bandwidth between AmLight connectors and I2 AL2S from 20G to 100G. Very soon.
- Full support for OpenFlow between AmLight and Internet2
  - Internet2 AL2S and AmLight SDN directly connected via OSCARS