AmLight Express and Protect (AmLight-ExP): Enabling Research and Education in the Americas via cooperation and collaboration

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# AmLight Express & Protect Vision

Backbone: AMLIGHT



- Community-operated network infrastructure
- Leased capacity on two submarine cable systems, evolving to a hybrid model that includes spectrum from Boca Raton to Sao Paulo
- Express (spectrum) capacity will provide up to 6 optical channels, which will be lit with 100G transponders today
- Protect (leased) capacity ring will back up the Express capacity



# Partners and Goals

AmLight-ExP interconnects the U.S. to key aggregation points in South and Central America (Brazil, Chile, Panama)

Cooperative and collaborative partnerships with ANSP, RNP, CLARA, REUNA, AURA, FLR, and Internet2

Continues evolving a rational network infrastructure using both optical spectrum and leased capacity













# **Cooperation and Collaboration**

- Sharing physical resources
  - Network Links
  - Colocation
  - Compute resources
- Sharing operations resources
  - Network Engineers
  - Service Level Agreements (SLAs)
- Supporting science and education in the Americas
  - Astronomy community: cooperation and collaboration in SAACC
  - Large Synoptic Survey Telescope (LSST)
  - High-energy physics community in Brazil
  - Etc.



## **Regional Network Infrastructure**

- 100G ring Miami-Fortaleza, Fortaleza-Sao Paulo, Sao Paulo-Santiago, Santiago-Miami
  - San Juan PR added in Q2 2018
- 10G ring from Miami-Sao Paulo-Miami for protection (red)
- 10G Miami-Santiago for protection
- 100G and 10G rings are diverse, operating on multiple submarine cables
- Total upstream capacity presently at 230Gbps





### Monitoring and Measurement

- Each AmLight PoP has a 10G perfSonar node with two NICs (BWCTL and OWAMP)
- Two 100G network taps installed in Miami to support the IRNC AMIS project
- One 100G network tap being installed between Sao Paulo and Santiago
- Maddash portal available





# Build Express backbone, and enhance resilience to AmLight

#### Activate Express spectrum:

- Two 100G channels via Fortaleza (Q3 2018)
- One direct 100G channel from Miami to Sao Paulo (Q4 2018)
- Add Panama to the 100G Protect ring: (Q4 2018)
  - Miami, Fortaleza, Sao Paulo, Santiago, Panama, Miami
- Enhance resilience to the AmLight-ExP backbone
  - Monet submarine cable bypasses the Caribbean





## Network virtualization and programmability

- Supporting SDN since 2014
- Researchers use slicing/virtualization to prototype network-aware applications
  - Can implement testbeds with real network devices
  - Can validate their research in a production environment, and at scale
- New sites with network virtualization using Corsa switches:
  - Sao Paulo, Brazil; and Santiago, CL
- Experimental deployment of bandwidth prioritization and reservation
  - In a multi-vendor environment (Corsa, Brocade, Dell)
- Integration of both optical and packet domains for a complete network visualization (SDN-LG for troubleshooting)





# **Opportunities:** Bandwidth abundance

- AmLight-ExP will have access to 225GHz of linear spectrum on Monet
  - Goal is to channelize this spectrum in 6x37.5GHz channels
  - Resulting in 6x100G ethernet circuits, initially
  - 200G of Protect (leased) capacity
- Improving international transit in Florida to Internet2 by adding protection to 100G transport



# **Opportunities: LSST**

- LSST is a large-aperture, wide-field, ground-based optical telescope under construction in northern Chile
- The 8.4 meter telescope will take a picture of the southern sky every 17 seconds
  - producing a 13 Gigabyte image
- Each image must be transferred to the archive site at NCSA in Champaign, Illinois, within 5 seconds
  - Reason: for processing to be completed in time to generate "transient alert" notifications to the worldwide astronomical community within 60 seconds
- In response to LSST's transient alert requirements, the network must be scalable, highly available, reliable, and provide high-throughput and guaranteed bandwidth





# Challenge: LSST Use Case

- Inter-domain coordination challenge example
- Hybrid networks, multiple network paths, multiple vendors equipment, multiple network operators
- Strict SLA:
  - MTBF (180 days in a year)
  - MTTR (48 hours)
  - 5 sec 13GB image transfer time, every 27 seconds





## Opportunity: Improving Network Troubleshooting

- Troubleshooting network transient events is complex and time consuming using legacy technologies (ICMP, SNMP, NetFlow, etc.)
  - Transient events refer to network anomalies that are difficult to trace, but cause disruption, such as micro bursts, intermittent congestion, etc.

#### Tracking transient events in real time is complex and costly, because

- Monitoring flows in real time overloads network resources
- Polling SNMP or OpenFlow counters is costly in sub 30 second intervals, because of CPU consumption
- LSST promises to change the paradigm of how network troubleshooting will be conducted
  - LSST data transfer must complete in less than 5 seconds
  - A 0.001% of packet loss will compromise the LSST application
  - Packet loss isolation will have to be handled in real-time
- Network operators need new tools to monitor flows in real time without impacting network performance



### **Opportunity: In-band Network Telemetry (INT)**

- AmLight-INT is a new project, funded by NSF, that will include telemetry functions in the AmLight network links
- In-band Network Telemetry (INT) is a framework designed to allow for the collection and reporting of network state by the Data Plane
  - without requiring intervention or work by the Control Plane
- INT enables new network troubleshooting functionality:
  - (1) Network troubleshooting Micro-burst detection, trajectory sampling;
  - (2) Advanced congestion control;
  - (3) Advanced routing, for instance, utilization-aware routing; and
  - (4) Network dataplane verification
- AmLight-INT will respond to the LSST SLA requirements by enabling real-time network troubleshooting functions



# Opportunity: New submarine cables in the South Atlantic

- Monet: Boca Raton, FL-Fortaleza, BR. Operational
- South Atlantic Cable System (SACS): Fortaleza, BR- Sangano, Angola. Q3 2018
- South Atlantic Inter Link (SAIL): Fortaleza, BR - Kribi, Cameroon. Q3 2018 (TBD)
- EllaLink: Fortaleza, BR Sines, Portugal. RFS 2020
- America Movil (AMX-1): Fortaleza, BR - Jacksonville and Hollywood, FL. Operational
- SABR: Cape Town, SA Recife, BR. RFS 2019
- Fortaleza is a landing point for all cables, except for SABR





#### AARCLight: Network infrastructure resources in the Southern Hemisphere (potential leveraging)

- 225GHz linear spectrum of Monet committed in AmLight-ExP project
- 40GHz of spectrum on SACS is available to the R&E community
- TENET operates 220G of capacity on WACS
- South Atlantic eXchange point (SAX) is under development in Fortaleza, led by RNP
- R&E exchange point in Cape Town operated by SANREN and TENET
- R&E exchange point in Lagos, operated by WACREN





# Conclusión

#### Nuestro Proyecto esta

- Desarrollando una infracstructura que interconecta a Norte America con puntos de agregación claves en Sur y Centro América (Brazil, Chile, Panamá)
- Evolucionando como una infraestructura de red academica fiable, flexible, y eficiente
- Facilitando un peering efectivo entre redes academicas y comunidades de interes
- Cumpliendo con los requerimientos de aplicaciones cientificas
- Continua su exito a traves de cooperacion y colaboracion



# THANK YOU!















### **Opportunity: Hybrid Network Operation**

#### Intra-domain coordination is changing

- Integrating spectrum and leased capacity into the SDN operation
- More complexity in the SDN Controller configuration

Inter-domain coordination across multiple network operators is becoming more complex

- Social engineering challenge
  - Impact to application will involve ALL network operators in the path
- Multiple vendor technology interoperability challenges
- Inter-domain troubleshooting challenges



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  - Association of Universities for Research in Astronomy (AURA)
  - Florida International University
  - Latin American Research and Education community



# Current Status: Network Virtualization and Programmability

- AmLight became an SDN network in 2014
- Slicing for network testbeds using OpenFlow 1.0
- Virtualization using Corsa switches for network testbeds using OpenFlow 1.3
- Researchers use slicing/virtualization to prototype network-aware applications
  - Can implement testbeds with real network devices
  - Can validate their research in a production environment, and at scale
- Current testbeds:
  - ONOS/CasTOR, FIBRE, Kytos E-Line, Awave-SDX
- SDN Looking Glass tool for troubleshooting the data plane





# Opportunities: Fortaleza and Southern Hemisphere

- New data-intensive science instruments in the southern hemisphere:
  - SKA in South Africa
  - Large Synoptic Survey Telescope (LSST) in Chile
- New submarine cables in South Atlantic
  - SACS submarine cable to Angola (RFS Q3 2018)
  - South Atlantic Inter-Link (SAIL) to Cameroon (2018)
  - EulaLink submarine cable from Fortaleza to Portugal (2020)
- Network aggregation in the southern hemisphere
  - Fortaleza as a south Atlantic hub
- Leveraging network infrastructure linking the U.S., South America, and Africa



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