AmLight ExP
Americas Lightpaths Express & Protect

South American – African Astronomy Coordination Committee (SA3CC) Meeting 2023

AmLight: International Connectivity

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Outline

- What is AmLight?
- Network Connectivity
- Network Provisioning & Operation
- How AmLight supports the SA3CC community
- Conclusion

What is AmLight?

- A distributed academic exchange point built to enable collaboration among Latin America, Africa, and the U.S.
- Supported by NSF, OAC, and the IRNC program under award # OAC-2029283 for 2021-2025
- Partnerships with R&E networks in the U.S., Latin America, Caribbean and Africa, built upon layers of trust and openness by sharing infrastructure and human resources

AmLight ExP
Americas Lightpaths Express & Protect
(NSF Award # OAC-2029283)

NSF 2021-2025 AmLight-ExP Project

- Vision:
  - Continue enabling collaboration among researchers and network operators in Latin America, Africa, and the U.S. by providing reliable, sustainable, scalable, and high-performance network connectivity and services.

- Focus:
  - Supporting Service Level Agreement (SLA)-driven science applications
  - Improving network visibility and management
  - Enabling integration between AmLight and network-aware science drivers
  - Adding new network and cloud services
  - Minimizing the human role in network operation

Network Connectivity…

Network Connectivity

- 6x100Gbps of upstream capacity between the U.S. and Latin America, and 1x100Gbps to Africa
  - Ongoing actions for 2023/2024:
    - Extending spectrum on Monet from 75GHz to 112.5GHz
      - Adding 2x100Gbps between Brazil to the U.S.
    - Activating spectrum on TANNAT at 112.5GHz
      - Adding 4x100Gbps between Brazil and Argentina
    - Support LHC, Astronomy projects, network experimentation, SuperComputing experiments, and FABRIC

- 2+ Tbps of international connectivity
  - Mix of optical spectrum, optical waves, lit capacity, and shared services

- Multiple points of presence: Florida(3), Brazil(2), Chile, Puerto Rico, Panama, and South Africa
  - Ongoing action for 2023: Expanding to Atlanta, with 4x100Gbps of total capacity over spectrum and dedicated connections, to ESnet and FABRIC

Network Connectivity – Updates since 2022

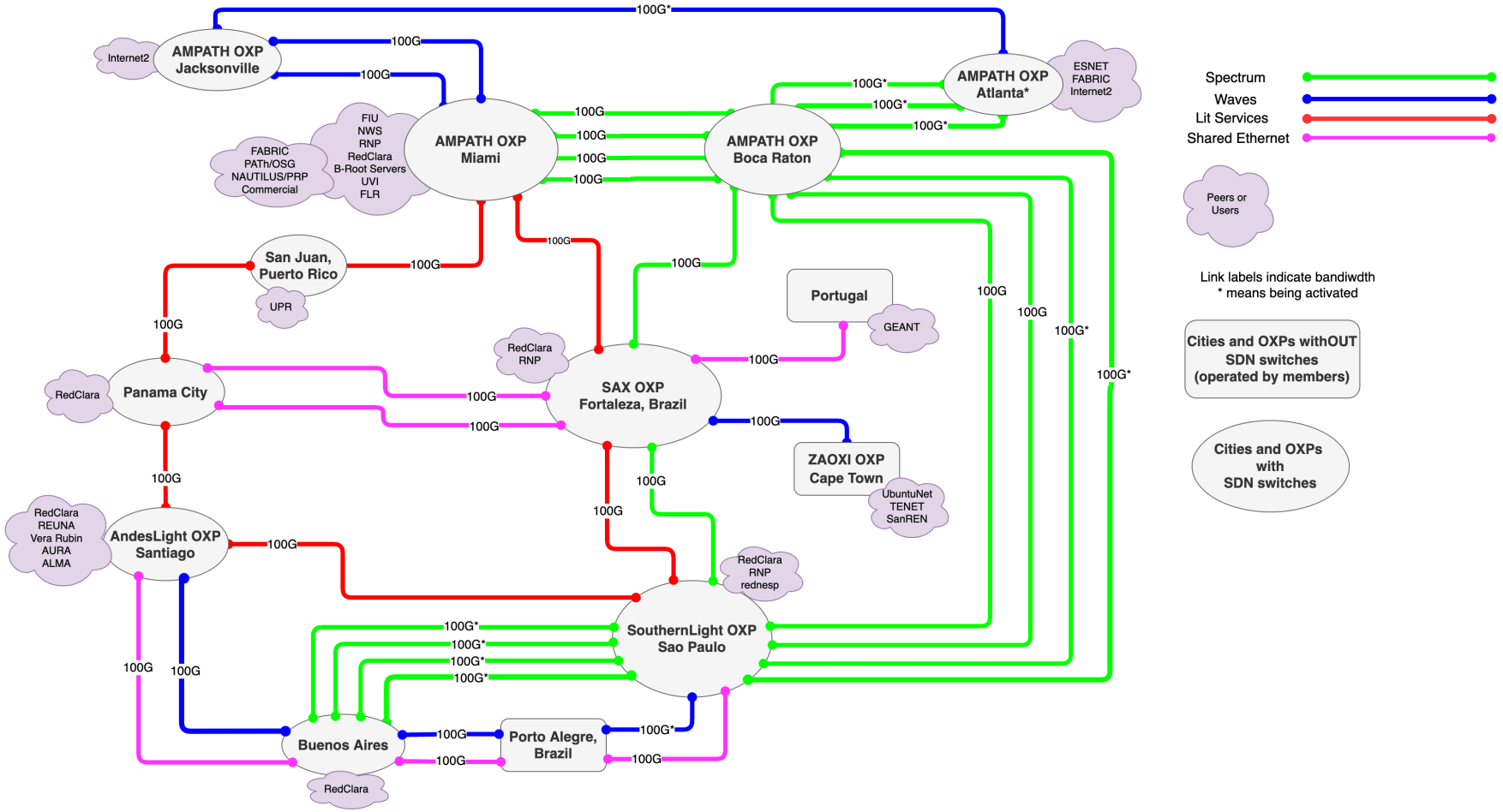
- In 2022/2023, AmLight's main focus was on:
  - Replacing legacy network devices for fully programmable P4 switches
  - Improving network resilience by adding new links
  - Lowering OPEX (power consumption and rack space utilization)
  - Increasing the number of 100G access interfaces for users and science drivers
  - Improve network visibility

- Currently in production, there are 13 programmable switches:
  - Miami: 2 (2022) + 3 (2023)
  - Boca Raton: 1 (2021)
  - San Juan: 2 (2023)
  - Sao Paulo: 1 (2021) + 1 (2023)
  - Santiago: 1 (2022)
  - Panama City: 1 (2022)
  - Jacksonville: 1 (2022)

In 2023, 10 new switches will be added to production:

Miami: 3
Boca Raton: 1
Santiago: 1
Jacksonville: 1
Atlanta: 2
Buenos Aires: 2

AmLight SDN Long-haul Links - 2023/2024

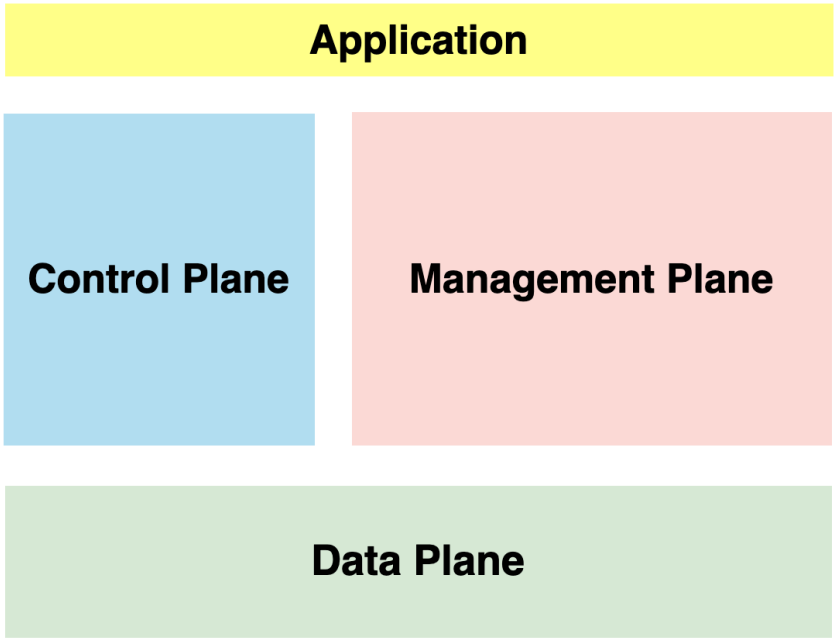


Network Provisioning…

AmLight SDN Architecture – 2014 - 2020

- From 2014-2020, we followed the "basic" SDN layers as in [1]
  - Application, Management, and Control Planes were very coupled under the same controller/orchestrator:
    - Each SDN Plane was operated as modules of the SDN controllers' software stack
  - Data Plane was a blend of vendors (Dell, Corsa, Brocade) with mixed support
  - Southbound Interface was OpenFlow 1.0 and OpenFlow 1.3

- The AmLight SDN Controller was responsible:
  - Provisioning L2VPN services
  - Handling fiber cuts and device outages by finding backup paths.
  - *Load balance had to be performed manually.*

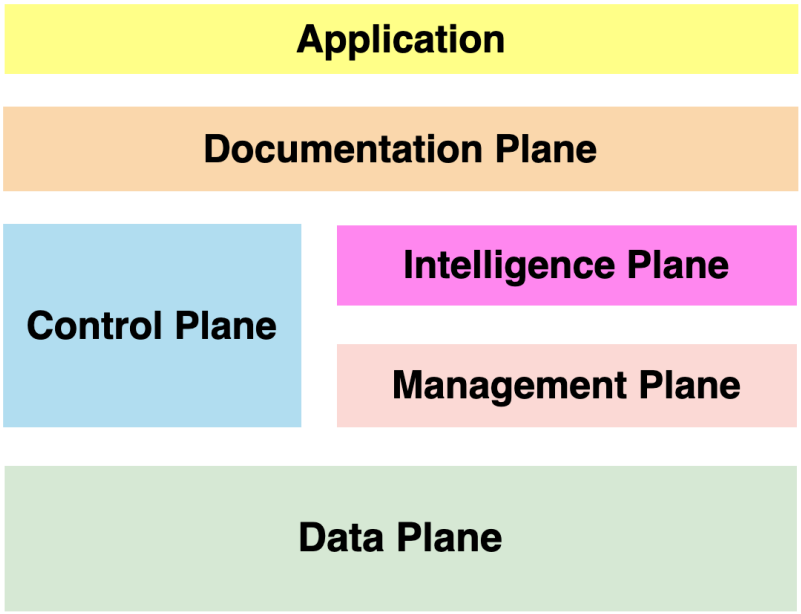


[1] IETF RFC 7626 & RFC 8597

AmLight SDN Architecture – 2021-2025

For 2021-2025, AmLight is enhancing its Software-Defined Networking (SDN) framework:

- New Data Plane based on programmable network device:
  - NoviFlow/EdgeCore P4 programmable switches
- New Management Plane for enhanced network visibility:
  - P4/In-band Network Telemetry (INT) for programmable switches
  - Juniper JTI for Juniper routers
- Brand-new Intelligence Plane:
  - The *Behavior, Anomaly, and Performance Manager* (BAPM) is being developed to learn the network state and create a sub-second closed-loop control
  - The 2023 IEEE NOMS paper "*An Adaptive and Efficient Approach to Detect Microbursts Leveraging Per-Packet Telemetry in a Production Network*" described one of the goals of BAPM.
- Brand-new Control Plane:
  - Kytos-ng SDN controller



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Control Plane: Kytos-ng

- Kytos-ng is the next generation of the Kytos SDN Platform:
  - Open-source SDN controller since 2017
  - Maintained by **FIU** and **rednesp** since May 2021
  - First Kytos-ng release was launched on Feb 15th, 2022
  - Available at *https://github.com/kytos-ng*

- Development focused on the AmLight operation requirements:
  - Pathfinder with support for multiple metrics and restrictions:
    - # of hops, minimum delay, max bandwidth, ownership, reliability, priority, average bandwidth utilization
  - Integration with In-band Network Telemetry to add per-packet telemetry
  - Supports for bandwidth reservation and prioritization
  - Supports for multiple southbound protocols OpenFlow 1.3+ and gRPC (P4Runtime)
  - Support for Point-to-Multipoint, BFD, VLAN range in the roadmap

Intelligence Plane

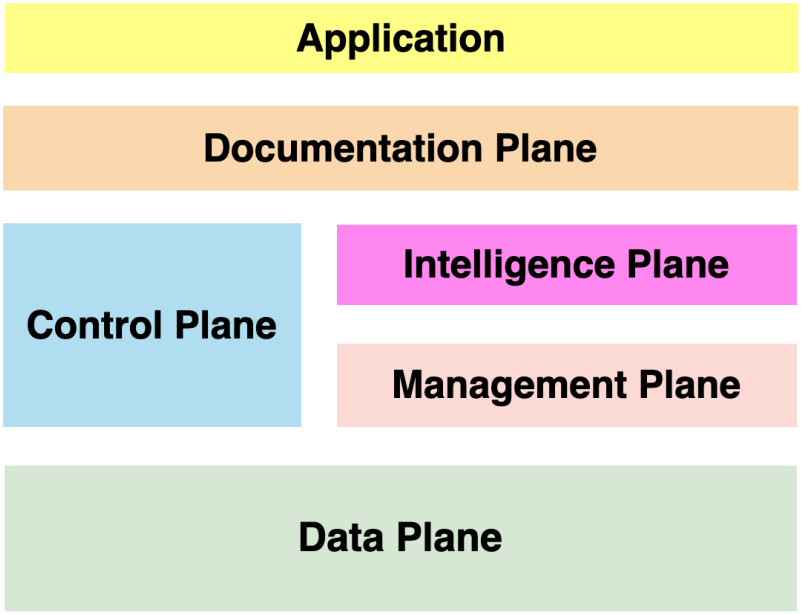
1. *Gets inventory, policies, and services from the Documentation Plane*
2. *Gets telemetry reports from the Management Plane*
3. *Profiles AmLight's traffic every 100-500ms*
   - *Discovers performance issues and traffic anomalies*
4. *Makes suggestions to the Control Plane*
   - *Steer traffic, Load balance services, Rate-limit anomalies*

Change of mindset compared to the previous AmLight-ExP project

- Creates the SDN closed-loop control to include policies
- Goal is to be prepared for sub-second reaction and debugging

Example of policies:

- If (80+% BW utilization >= 2s), then load-balance
- If (50+% [Queue Occupancy] >= 2s), then steer traffic
- If (Number of path changes >= 5 in 2h), then set *maintenance_mode*



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How is AmLight supporting SA3CC?

- AmLight has a complex topology with plenty of paths and bandwidth:
  - From Chile to Jacksonville, there are more than 25 possible paths to take
  - With the new architecture, we expect to properly load balance network services across links, while respecting user constraints and requirements

- AmLight will handle any SLA-driven packet-loss-intolerant and sub-minute-response-time-expected science application:
  - With per-packet telemetry and sub-second network profiling capacities, AmLight will be prepared to react to network conditions under 1 second
  - AmLight aims anticipate issues with the substrate and steer traffic out of the substrate before adverse events happen

- Focus on engineering and automation:
  - With the closed-loop control, time-consuming operational activities will be performed without human intervention

Recent Presentations

- Understanding the impact of network microbursts to science drivers - 07/07/2023
  - https://youtu.be/_wronGw48os
  - CI Engineering Lunch & Learn Series
- Detecting Network Microbursts at AmLight - 04/21/2023
  - https://youtu.be/1x-aVZTyyiM
  - CI Engineering Lunch & Learn Series
- In-band Network Telemetry at AmLight - 03/18/2022
  - https://youtu.be/M6n_UZlhBQQ
  - CI Engineering Lunch & Learn Series
- Autonomic Network Architecture at AmLight - 02/25/2022
  - https://youtu.be/CRnKKuP9I3Y
  - CI Engineering Lunch & Learn Series
- Deploying per-packet telemetry in a long-haul network - 11/21/2021
  - https://www.youtube.com/watch?v=lVtY7dP7UGs&t=2s
  - INDIS Workshop

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