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Migrating AmLight from legacy to SDN: Challenges, Results and Next Steps

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Agenda

- Who are we?

- What is SDN?

- Step by Step with use case

- Future

Who we are

- AMPATH:
  - Academic IXP based in Miami
  - Interconnects Latin America RENs to other RENs in the world

- AmLight:
  - A set of 4 x 10G links used to connect Latin America RENs to AMPATH

- Partnership among FIU, NSF, ANSP, RNP, RedClara, AURA and REUNA

Recap: What is SDN?

- *Software Defined Network* decouples Control Plane from Data Plane:
  - Forwarding decision managed by an external network controller

- Standard interface for the communication between the network controller and the switches:
  - A standard protocol was developed: Openflow
  - Openflow 1.0 and 1.3 is deployed and supported by lots of vendors
  - Most of the current switches which supports OpenFlow supports Hybrid Mode
    - Some ports using OpenFlow, some ports using legacy protocol
  - Some switches also support Hybrid Ports
    - OpenFlow and legacy traffic in the same port
    - Useful for an easy and incremental deployment

But what is SDN? (2/2)

- With SDN, the network controller would be responsible for all network configurations:
  - Network connectivity, including a loop-free topology
  - Rate-limits, priorization, statistics
  - And new services/deployments:
    - Security, new protocols, new applications, etc.

- Do you want to go deeper?
  - Open Networking Foundation:
    - https://www.opennetworking.org
    "Software-Defined Networking: The New Norm for Networks"
    "SDN Migration Considerations and Use Cases"

  - Openflow Specifications:
    - https://www.opennetworking.org/openflow-conformance-certification

Step by Step to migrate to SDN:
AmLight Use Case

Step 1: Know your network

- Document everything you have in operation:
  - Link Aggregation/LACP,
  - VLANs/Spanning-Tree/QinQ,
  - MPLS/Routing/L2VPN, L3VPN, QoS,
  - Fast ReRoute, BFD,
  - Port Mirroring, IPS/IDS

- Knowing what you have will help you choose controllers and applications
  - It doesn't mean you will find applications that support everything!

Step 1: Know your network (2)

- AmLight's Operations are based on Layer 2
  - Layer 3 services are managed between users and AMPATH

- At AmLight we had:
  - Link Aggregation (MCT + LACP)
  - VLANs + per VLAN Rapid Spanning-Tree
  - Port Mirroring

Step 2: Assessments of your devices

- Supported protocols:
  - Openflow
    - Which version?
  - Netconf, Yang?

- Openflow implementation phase:
  - Beta, Testing or stable?

- Openflow's *Optional* features
  - Metering, Port Group, LACP, etc.

- Is Hybrid port supported?

Step 2: Assessments of your devices (2)

AmLight use case:

- Brocade MLXe/XMR/CES switches:
  - Openflow 1.0 and 1.3 (1.3 started on Dec 2014)
  - Amount of flows supported
    - MLXe (-D)/XMR: 64k flows (per-system and per-module), 4k per port
    - CES: 4k flows (L2) or 2k flows (L2/L3)
  - Support for Hybrid port
    - MLXe/XMR: 2k Protected vs 4k Unprotected VLAN IDs
    - CES: Doesn't support Hybrid Port
  - Amount of controllers supported
    - MLXe/XMR and CES: 3 (active or passive)
    - SSL optional (max of two)
  - Kind of matches supported:
    - MLXe/XMR: L2, L3, L2/L3 (L2/L3 only on 8x10G and 2x100G)
    - CES: L2 and L2/L3 (L3 in future)
  - Default actions:
    - Drop packets or Sent to controller
  - Statistics per Flow
    - MLXe/XMR: all
    - CES: First 2k flows

Step 2: Assessments of your devices (3)

- Brocade MLX/XMR/CES (cont.)
  - Layer 2 Control Protocols not supported on Openflow ports (even hybrid ports)
    - No STP, RSTP, etc.
  - Only 40 legacy VLANs supported on Hybrid Ports
  - No switching from LOCAL and NORMAL ports
    - Openflow and Legacy don't talk between them
  - Gen1 switching modules (4x10G) only support LLDP for generic flows
    - Also have counters limitations
  - Link Aggregation is not supported

- Network devices' hardware will always matters!
  - There will always be limitations due to the chosen internal components

Step 3: Openflow Controller and Orchestrator

- **Controller vs Orchestrator**
  - Controller: manages the southbound interface
  - Orchestrator: businness application
- **In-house development? Use one available?**
  - Does it support your applications/services in use?
- **Do you need network virtualization/slicing?**

Controller	Interface(s	Lang	Modules				Licens	OF 1.3
			Discov	Host	Topo /	MultiPro		
NOX	Native/WS	C++	Yes	yes	yes	no	Apache	branch
POX	Native/WS	Python	Yes	Yes	Yes	no	GPLv3	
FloodLight	Native,WS	Java	Yes	Yes	Yes	no	Apache	no date
OpenDayLight	Native,WS	Java	yes	yes	yes	yes	EPL	yes
RYU	Native/WS	Python	yes	yes	Yes	Yes	Apache	yes

Step 3: Openflow Controller and Orchestrator (2)

AmLight Use Case:

- OpenFlow 1.0

- Controller: NOX

- Orchestrator: Internet2 OESS
  - Supports Layer 2 provisioning via Web User Interface
  - Supports OSCARS (multi-domain provisioning – useful for RENs)

- New feature added:
  - Network Virtualization: FlowSpace Firewall
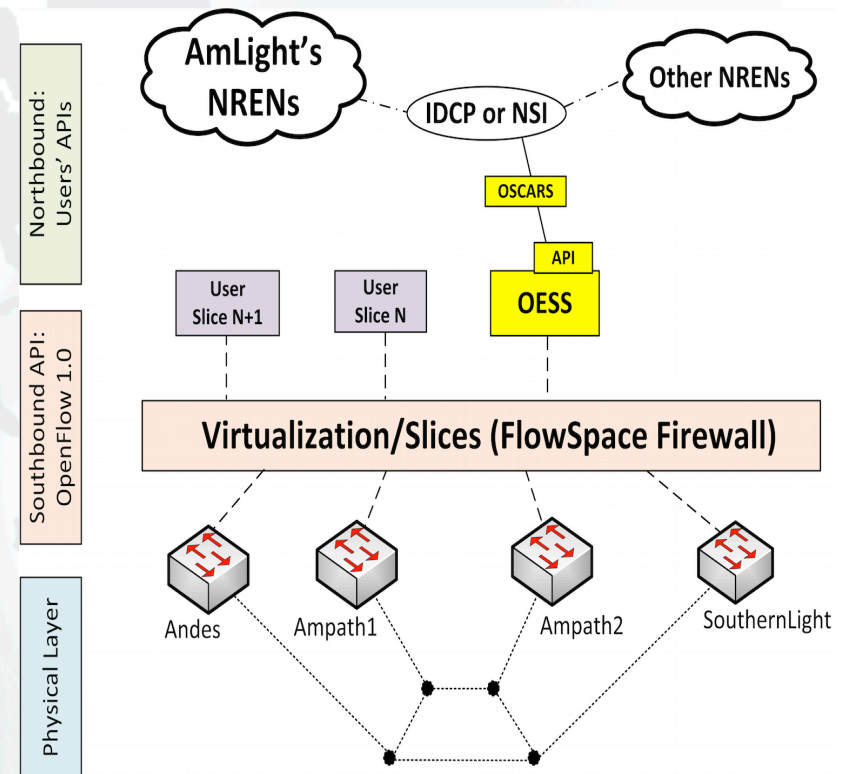
Step 4: Openflow control plane network

- ## Where to place the controller?
  - Important question for WAN, not that much for Campus/Datacenters
  - How many controllers?
    - One per site, One per domain?

- ## How to reach all network devices from controller?
  - In band?
    - Most vendors don't support Openflow messages over Openflow flow entries
  - Out of Band?
    - Is there connectivity restraint? New interfaces required?

Step 4: Openflow control plane network (2)
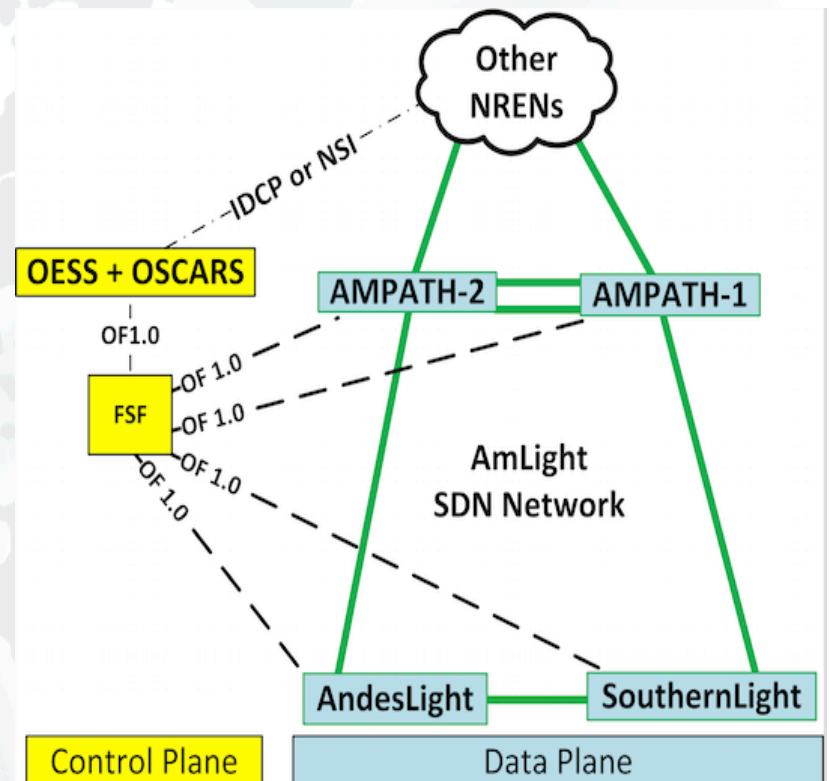
AmLight Use Case:

- 2 switches in Miami
- 1 switch in Brazil (SouthernLight)
- 1 switch in Chile (AndesLight)

Ring topology:

- Just two links per switch
- Chile's switch doesn't support hybrid port

Final configuration:

Out of band through a third party network

Controller in Miami (closed to the "SDN" Engineers)

Step 5: Security

- Use SSL or not for the control plane?
  - With SSL: secure communication, not all controllers support. Hard to troubleshoot (*tcpdump*)
  - Without SSL: insecure, all controllers support, easy troubleshooting
- Control the amount of flows per slice/virtualized network
- Create flow insertion rate-limit per slice/virtualized network
- How to troubleshoot in a passive way through a secure approach?

Step 5: Security (2)

AmLight Use Case:

- Use SSL or not for the control plane?
  - Without SSL: easy troubleshooting
  - Limited to 4000 L2/L3 flows (360 in use)
  - 40 flows/sec flow insertion rate-limit (15 observed)

- How to troubleshoot in a passive way through a secure approach?
  - Working on it!

Step 6: Deployment

- New skills required: Linux, Log Reading, Coding (Python or Java), etc.

- Start with *mininet*, try to reproduce your services and configurations

- Create a testing environment with real switches and, if possible, the same vendors and models

- If possible, deploy it gradually, for example, start with layer 2 services

Step 6: Deployment (2)

AmLight Use Case:

- Started on April 30th, Deployed on August 30th

- A few tools developed for troubleshooting

- New skills acquired: Openflow and Python (Linux was part of our routine)

Lessons Learned

- Train your team, document everything
  - Be prepared to develop some code: no controller will support everything you need

- Keep your testing environment available:
  - Every required change and/or upgrade in the future must be tested/applied on this environment

- Be prepared for surprises and crashes:
  - No vendor/switch is mistake-free.
  - Have you Disaster Recovery Plan ready

Future

- Define a methodology to
  - test new vendor/controller software;
  - validate new Openflow switches;
  - troubleshoot;
  - validate the OpenFlow forwarding actions are working;
- Deploy New Applications?
  - DDoS control (ONS 2014 IDOL)
  - Software Defined Internet Exchanges (SDX)

AmLight Today: Results

Provisioning:

	Average time to provision a new circuit		Avg. number of e-mails exchanged	
Domains involved in the path	*before SDN*	*after SDN*	*before SDN*	*after SDN*
RNP, ANSP, RedCLARA, AmLight, Internet2, ESnet	5 days	< 5 minutes	10	0
Other domains using OSCARS or NSI support	12 days	< 5 minutes	65	0

Programmability:

	Network Access and Programmability	
	Before SDN	After SDN
Network View	SNMP	SNMP and Openflow
Provisioning Defined by the User	-	Full Openflow access through a dedicated slice
Multipath experiments	Static paths offered	
Flow controlled hop-by-hop	-	