VIII Workshop on Future Internet Research and Experimentation (WPEIF)
May 19th

Mitigating the Risks of Supporting Multiple Control Planes in a Production SDN Network: A Use Case

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Outline

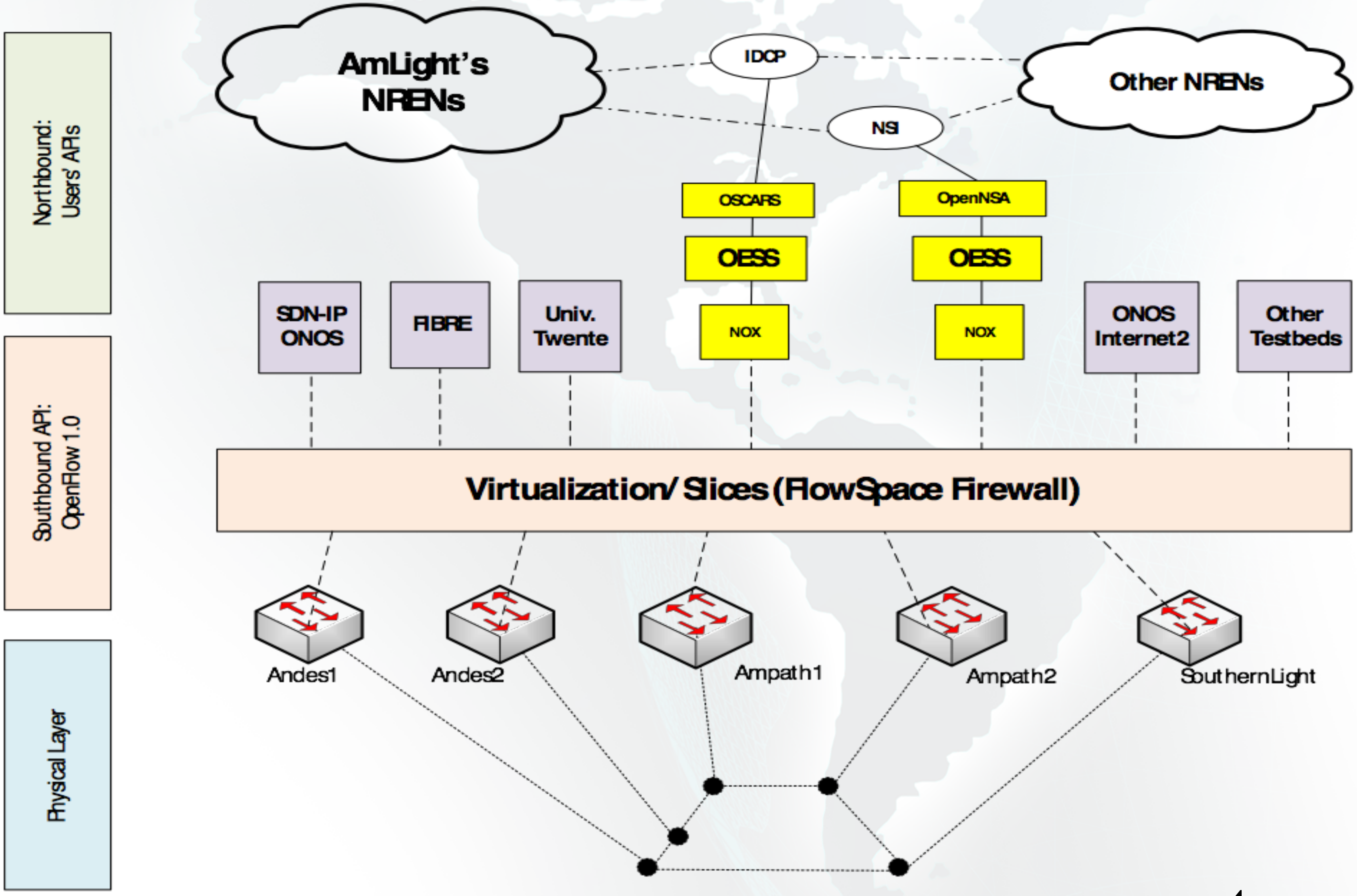
- Context
- Motivation
- Architecture
- Methodology
- Results
- Future

Context

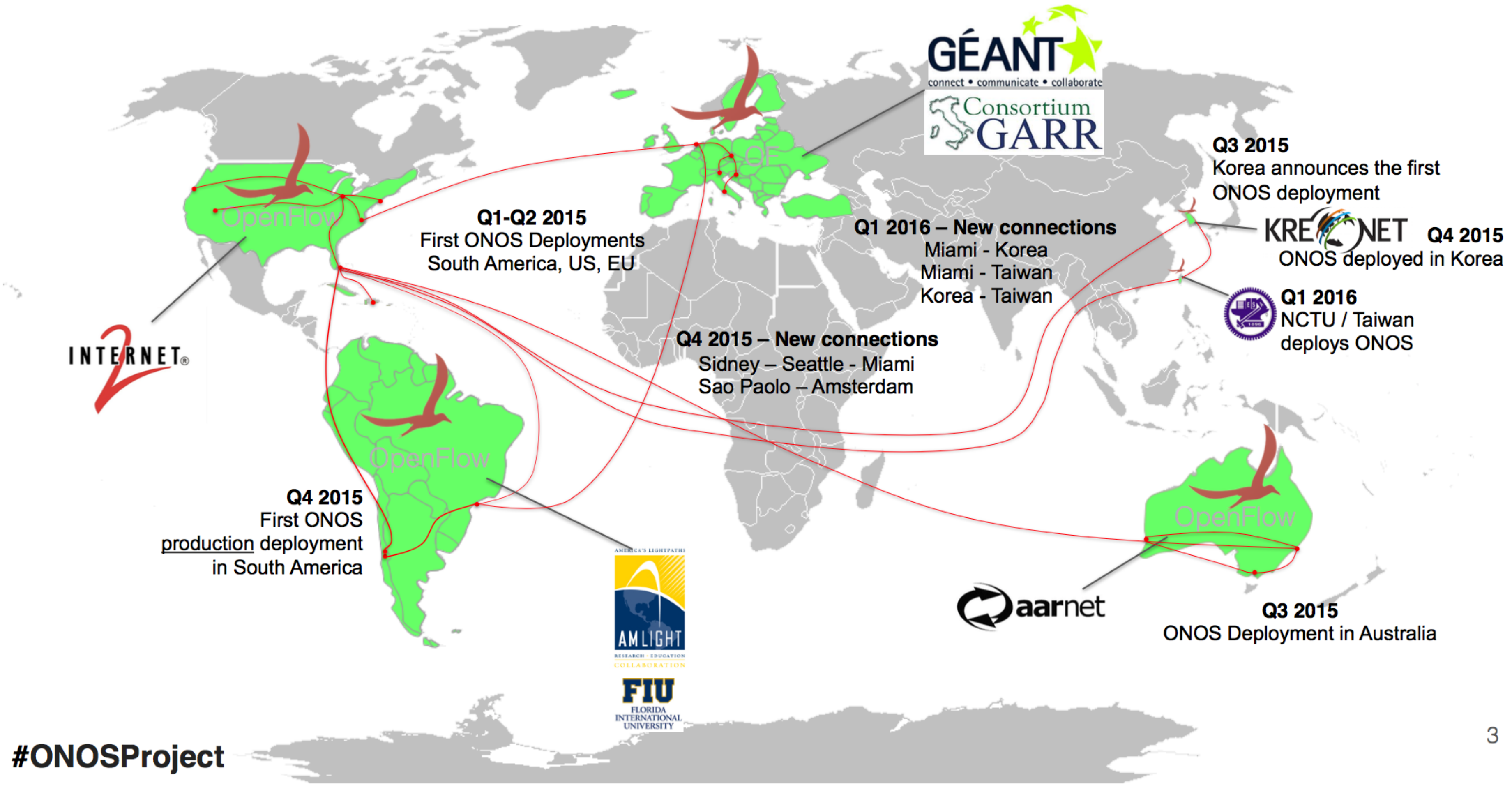
AmLight is a Distributed Academic Exchange Point

- Production SDN Infrastructure (since Aug 2014)
- Connects AMPATH and SouthernLight GLIF GOLES
- Carries Academic and Non-Academic traffic
  - L2VPN, IPv4, IPv6, Multicast
- Supports Network Virtualization/Slicing
  - Openflow 1.0
  - Flow Space Firewall for Network Virtualization/Slicing
  - OESS for L2VPNs
  - NSI(OpenNSA+OESS) and OSCARS enabled
    - Including AMPATH and SouthernLight
  - Currently 4 slices for experimentation (including ONOS SDN-IP)

Context (2)


Northbound: Users' APIs
Southbound API: OpenFlow 1.0
Physical Layer
AmLight's NRENs
IDCP
Other NRENs
NSI
OSCARS
OpenNSA
OESS
OESS
SDN-IP ONOS
FIBRE
Univ. Twente
NOX
NOX
ONOS Internet2
Other Testbeds
Virtualization/ Slices (FlowSpace Firewall)
Andes1
Andes2
Ampath1
Ampath2
SouthernLight

Examples – ONOS SDN-IP @ ONS



Q1-Q2 2015
First ONOS Deployments
South America, US, EU

Q3 2015
Korea announces the first ONOS deployment

Q4 2015
ONOS deployed in Korea

Q1 2016 – New connections
Miami - Korea
Miami - Taiwan
Korea - Taiwan

Q1 2016
NCTU / Taiwan deploys ONOS

Q4 2015 – New connections
Sidney – Seattle - Miami
Sao Paolo – Amsterdam

Q4 2015
First ONOS production deployment in South America

Q3 2015
ONOS Deployment in Australia

#ONOSProject

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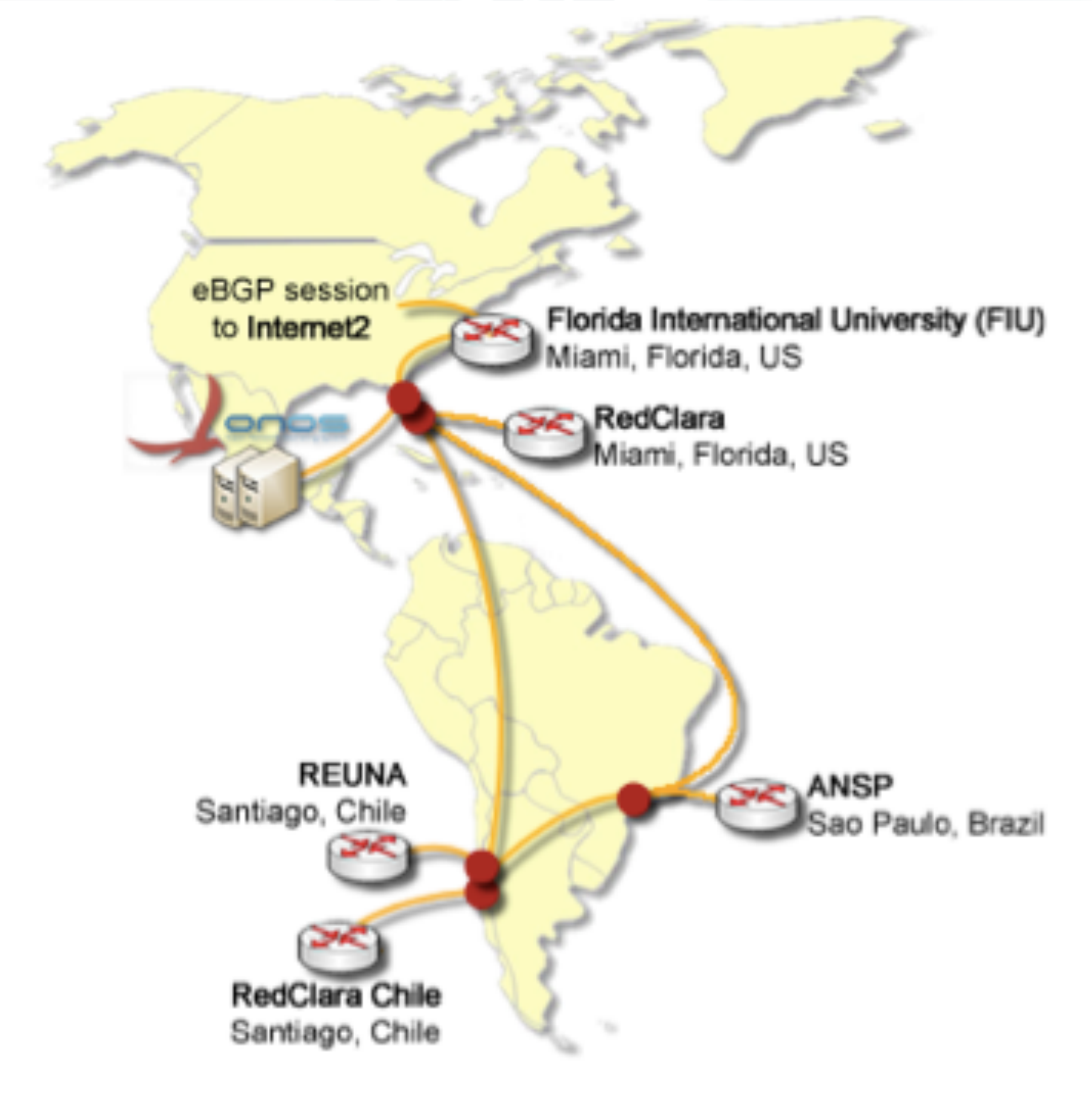
Examples (2) – ONOS SDN-IP @ ONS



Examples (3) – And more…

- In partnership with RNP:
  - FIBRE (*Future Internet testbeds / experimentation between BRazil and Europe*): how to use an OpenFlow native backbone to interconnect FIBRE islands (or racks)?
  - FIBRE island installed at AMPATH/Miami and using AmLight

- In partnership with Internet2:
  - Internet2 Technology Exchange 2014 – Multi Domain controller managing slices from different SDN domains (Internet2, AmLight, Univ. of Utah and MAX)
  - Internet2 Global Summit – ONOS SDN-IP demonstration

- In partnership with University of Twente:
  - *"Assessing the Quality of Flow Measurements from OpenFlow Devices"*
    - Hendriks, Luuk, et al. 8th International Workshop on Traffic Monitoring and Analysis (TMA), Louvain La Neuve, Belgium. 2016.
- All of them running on the same production infrastructure

Motivation

How to guarantee experimental applications won't affect my "production" slice?

- FlowSpace Firewall *slices* based on <switch,port,vlan>:
  - No extra filters are possible at this moment

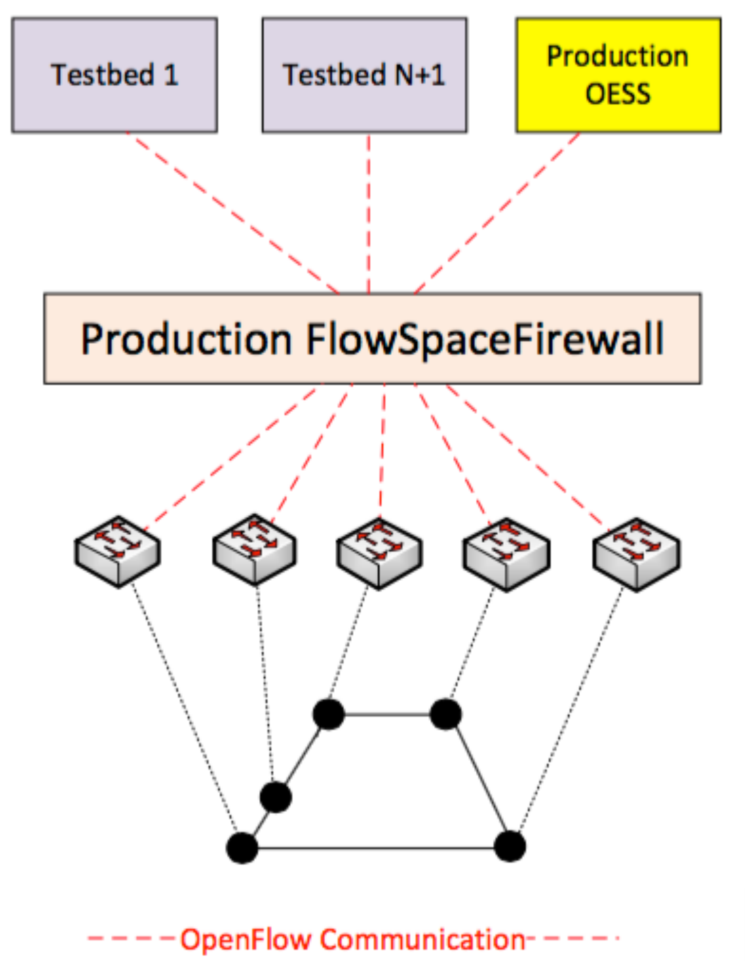
- Multiple OF controllers could manage the same OpenFlow device:
  - Complicated to isolate who is sending specific OF messages

- OpenFlow deployed by some vendors is still "experimental":
  - Unsupported messages could lead to a device crash - 20+ outages in the first year!

- Troubleshooting is still complicated:
  - Logs provided by the SDN stack is still poor

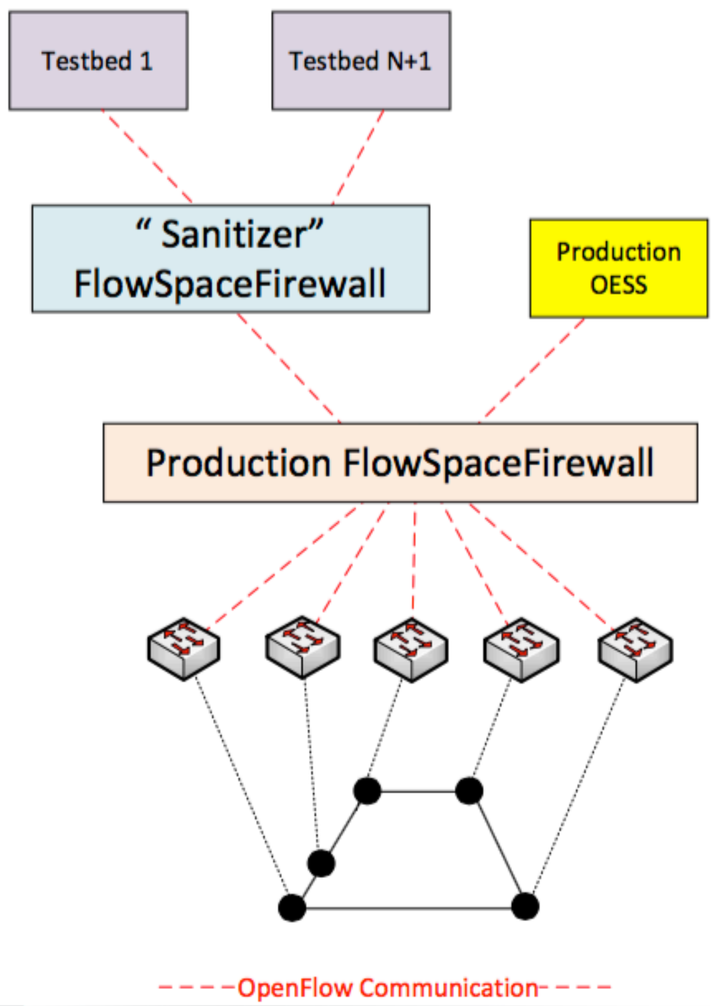
Architecture - Before

- Single FSFW interfacing all apps
- Troubleshooting done through *logs* and *tcpdump* captures
- A testing methodology in place before adding new testbeds:
  - *Understanding of the researcher's applications*
  - *Tests in lab prior adding to the production environment*
  - *AmLight and Researcher manage the SDN app together*
    - *Risky*
    - *Very time-consuming*
    - *A few crashes happened, hard to understand "why"*



New Architecture: Minimizing risks

- **Three main innovations:**
  - **An evaluation methodology**
  - **OpenFlow packet dissector (OF Sniffer)**
  - **OpenFlow packet filter (TestBed Sanitizer)**
- Two Layers of Virtualization
  - Main/Production Layer
  - Experimentation Layer
- OpenFlow Sniffer keeps monitoring all communication
  - To help vendors in their troubleshooting activities
- Experimentation Layer had a "Sanitizer" module added:
  - Controls what OpenFlow messages can be sent to the "Physical Layer"
  - Allows filters per OpenFlow Type, per-match and per-action
  - Off-loads switches from unsupported OpenFlow messages
- Sanitizer logs transactions and filters based on dictionaries:
  - XML files created as result of OF Tests
  - Detailed logs per slice or per type of message



Methodology

1. OF Tests
   - Each device, software version and line card type is stressed in lab
   - Unsuccessful tests are collected and processed
   - When a specific match or action is not supported, it is added to the dictionary

2. XML filters
   - Defines the Dictionary to be used by Sanitizer
   - They can be created through field experience (Network Operator)

3. Filters are stateless
   - Less powerful but easier to deploy and faster
   - Some issues require stateful filters (future work?)

Evaluation

- ONOS/SDN-IP vs Brocade CES:
  - ONOS sends all flows in a single batch command
  - Brocade CES doesn’t support MAC rewrite
  - ONOS logs only have “batch failed”
  - Tcpdump had to be used
  - Satinizer’s dictionary has a “CES and Mac-rewrite don’t mix” entry and log it

- Brocade CES NI 5.7 vs OpenFlow Vendor type:
  - Some OpenFlow messages type Vendor were forcing Brocade CES to restart the OpenFlow connection
  - Satinizer’s Dictionary has a “CES 5.7 doesn’t take unknown Vendor ID” filter and log it

- OESS Forwarding Verification vs Brocade MLX-4 4x10G line card:
  - Ethertype 0x88b6 not supported, internal trace logs rotating too fast
  - Satinizer’s Dictionary has a “LP 4x10G and Etype “A” don’t mix” filter and log it

Evaluation [2]

- FIBRE testbed vs Brocade MLXe:
  - During the evaluation process (step 1) the following challenges were found:
    1. FlowVisor expected to fully control the OF switches, not a slice
    2. Use of untagged VLAN is hardcoded into FlowVisor, but at AmLight, untagged VLAN was reserved for internal use
    3. FIBRE assumes that any OpenFlow controller can be used by the user but AmLight requires that all controllers needs to be validated through the evaluation methodology
    4. All OpenFlow features are provided to the FIBRE user. But, at AmLight, only risk-free features are allowed.
  - In response to these challenges we implemented the TestBed Sanitizer as described before.

Findings

- Most of the issues threatening network availability were stateful, not stateless. Stateful issues occur as a result of multiple messages, or a sequence of messages in a particular context.

- A testing methodology before adding anything to production is still required, once some issues require stateful/complex filters

- Off-loading some filters help switches to focus on "supported" features
  - Also preserves switches internal trace logs queue

Findings [2]

- With the innovations in place, all OpenFlow messages are traced effectively, and non-compliant OpenFlow messages are discarded in real-time.
  - The number of outages that resulted from these stateless non-compliant OpenFlow messages dropped substantially: from **15** network outages to **0** in the first year.

- New per-slice logging helps to identify which application sent a specific OpenFlow message
  - – Helps researcher to improve his/her SDN application

- Troubleshooting logs helps vendors to reproduce the issue

- It become evident that we should work with the vendor’s to improve its OpenFlow agent instead of investing in external security filters.

Future

- Testbed Sanitizer was a proof-of-concept to understand how complex and deep the problem is
- Future is unclear: should we develop a production sanitizer? Or should we “force” vendors to create a better code?
- Stateful filters are very important, but they are very complex to deploy
  - Research topic?
- OF 1.3 will be even more complicated: meters, multi-tables, etc.

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Thank You!

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