Integrating complex legacy systems under OpenFlow control. The DOCSIS use case

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Outlines

Motivation
Integration of DOCSIS under OpenFlow architecture
ALHINP proxy
Design
Tests
Conclusions and future work
SDN based architectures

• SDNs are becoming omnipresent today and can be found successfully applied over several parts of the network:
  • Datacenters, campus networks,…

• Sometimes it can be difficult to integrate due to
  • Complexity
    • How to deal with technology dependent parameters
    • Provisioning
    • Dynamicity
  • Presence of legacy equipment that has to be paid off
  • Access networks technologies
Integrating legacy devices

Integrations of non-Openflow devices can be performed in several ways:

• Native integration.
  • Modify software / firmware
    • Only suitable for vendors. (code not available)
  • Programmable devices
    • Custom integration limited by the capabilities of the device

• Develop an ad-hoc module into a controller
  • Develop a per-controller module

• Proxy based integration
  • Suitable when the device to integrate cannot be modified
  • Exposing a northbound interface (OpenFlow)
  • Southbound interface (platform dependent)
DOCSIS access network

Service provider installations

Provisioning servers
- DHCP
- Time server
- TFTP

Core Network
OpenFlow controlled DOCSIS access network

- Service provider installations
- User
- OpenFlow helpers
- Customer premises
- Cable modem
- CMTS
- Aggregation OpenFlow switch
- Provisioning servers
- Proxy
- Core Network
- DOCSIS

Diagram showing the network architecture with OpenFlow control.
Hardware used

CMTS Cisco UBR-7246VXR
• 12.2 Cisco OS
• NPE G1 processing engine
• L2VPN mode (1 VLAN <-> 1 Cablemodem )

Cablemodem Cisco EPC 3825
• bridged mode
• 4 Gigabit ports

OpenFlow User Instance
• Linux MiniPC dual core / 4GB RAM
• xDPd 0.4.3
• 4 Gigabit ports

OpenFlow Aggregation switch
• Linux PC QuadCore / 6GB RAM
• xDPd 0.4.3
• Intel 4 Gigabit port PCIe card
ALHINP architecture

ALien HAL Based Integration Proxy (ALHINP)

ROFL Libraries  https://www.roflibs.org

Features:
- Interface to controller: OF1.0 / OF1.2
- Internal OF version: OF1.2

repository

https://github.com/fp7-alien/alien-DOCSIS

Released under Mozilla Public license
DOCSIS Hardware Abstraction Layer

OpenFlow Controller

OpenFlow endpoint

Hardware Agnostic Part

OF messages (virtual identifiers)

Crofbase methods

• Abstracts port numbering and real DPIDs
• Hides events generated at internal ports

OF messages (real identifiers)

Translator

• Message dispatch, splitting and translation
• Packet Out performing
• Stats requests

Orchestrator

FLOW_MOD PORT_CONFIG PACKET_OUT FEATURES_REQ
FLOW_MOD PORT_CONFIG PACKET_OUT FEATURES_REQ

Packet IN PORT_STATUS FEAT. REPLY

Packet IN PORT_STATUS FEAT. REPLY

• Detects cablemodems
• Controls VLAN assignment
• Detects user-side switches and enables virtualization for each one

OF interface

DOCSIS Driver

CMTS & Provisioning servers

Enable L2VPN QoS provisioning

OF interface

OpenFlow user-side helper switches (xDPd)

Aggregation Switch (xDPd)

Packet IN PORT_STATUS FEAT. REPLY
CM detection & provisioning

QoS provisioning applied by the controller
- SET_BANDWIDTH
- Openflow match is mapped into Service Flow classifier
- The cablemodem is reconfigured with new service flows.
CM detection & provisioning

OUI detection process

Intentional PACKET_IN to establish the relationship between VLAN and DPID

OPENFLOW CONTROLLER

PORT_STATUS

ALHINP

VLAN traffic

Untagged traffic

OFP session

Cablemodem & Openflow User Instance

CMTS

Aggregation switch

Intentional PACKET_IN to establish the relationship between VLAN and DPID
VLAN support

How to handle dual VLAN tag with OpenFlow?
- Using metadata field combined with multiple tables (OF 1.2)

**TABLE 0**

<table>
<thead>
<tr>
<th>MATCH</th>
<th>ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLAN_VID</td>
<td>present</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 0 is used only for internal flows / actions
This entry is inserted per CM

**TABLE 1**

<table>
<thead>
<tr>
<th>MATCH</th>
<th>ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original match</td>
<td>Original match</td>
</tr>
<tr>
<td>METADATA</td>
<td>METADATA</td>
</tr>
<tr>
<td>VLAN_VID (user)</td>
<td>VLAN_VID (user)</td>
</tr>
</tbody>
</table>

Usage of metadata is also helpful for deleting only rules affecting to a CM in particular
Flow Mod performing

Actions always performed at egress switch

Flow mods installed in opposite direction to the flow

FLOW_MOD
  - IN_PORT: 21
  - MATCH { ...
  - TABLE 0
  - ACTION:
    - OUTPORT: 12

FLOW.MOD_part_2
  - IN_PORT: 1
  - MATCH { ...
  - TABLE 0
  - ACTION:
    - OUTPORT: netport (2)

FLOW.MOD_part_1
  - IN_PORT: netport (1)
  - MATCH { ... + METADATA}
  - TABLE 1
  - ACTION:
    - OUTPORT: 2
Packet Out performing

1. Packet_out OFPP_FLOOD
2. Packet_in
3. Packet_out OFPP_CONTROLLER
4. Packet_out 12

Controller
ALHINP

Packet_out 31
Packet_in
OFP_reason: controller

packet 21
packet 31

packet 12
**Testing**

**OF-TEST**
- Synthetic tests from Floodlight
  - False positives can be obtained

**OpenFlow controllers**
- POX (Tested @ TNC2014)
- Floodlight

**CONET: Cache Content Network**
- Integration over OFELIA network
- DOCSIS available as a resource in OFELIA
- Modified Floodlight controller for CONET
Integrate DOCSIS access network is feasible, however, it has to be surrounded with some helpers to complement the functionalities for a successful Openflow-switch-like behavior.

Integration of Openflow User interface into Cablemodem firmware should improve the performance of the solution. This would be the key of the integration we propose.

This proxy-based architecture can be easily deployed over different access technologies, developing the corresponding technology driver.
Future work

- Fine-grained AAA Service-Flow based schemes (already being investigated and developed, and partially demonstrated @FIA 2014)
  - Using different credentials for different services.
  - Moving away from MAC based authorization schemes to identity based ones.
- Advanced services
  - Support of user nomadicity, bandwidth lending...
- NFVization of elements
  - AHLINP
  - Provisioning system
  - AAA server
- Migration to other technologies
  - GPON
  - ADSL
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