Functional validation of the cooperation between Virtual Network Topology Manager and Path Computation Element

O. Gonzalez de Dios, M. Cuaresma, S. Martinez, F. Muñoz, V. Lopez, J.P. Fernández-Palacios

Telefónica I+D, Spain
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Motivation and Introduction
Motivation

• Current core networks are based on several layers.
• Mid-term scenario: IP/MPLS network over reconfigurable wavelength switched optical network (WSON).
• Two key elements to help in the management and coordination of such multi-layer architectures:
  – Path Computation Element (PCE)
  – Virtual Network Topology Manager (VNTM).
• PCE aim is to calculate the route between endpoints, especially in complex scenarios (e.g. WSON with physical impairments, multilayer or multidomain)
• VNTM is in charge of maintaining the topology of the upper layer by connections in the lower layer.
Introduction to the experiment

- This work shows an experimental validation of cooperation between a simple NMS, a multilayer PCE and a VNTM in an IP/MPLS over WSON scenario with commercial equipment.
- Testbed is composed by Juniper routers and ADVA optical nodes.
- Telefonica I+D has developed a prototype of both a multilayer PCE and a VNTM to demonstrate the feasibility of the approach.
02
Scenario Description
Testbed

- 3 Juniper MX240 routers representing an IP/MPLS network
- 4 ADVA optical nodes with wavelength switching capabilities representing a photonic mesh
- Simple NMS to configure routers.
- Multilayer PCE:
  - MPLS & WSON topology
  - TE information
- VNTM
  - Interlayer TE Link information (not available in PCE)
  - Virtual topology.
  - No WSON information
Validation Testbed

Physical Connectivity

- ML-PCE
- NMS
- VNTM

Traffic Generator

- JUNIPER MX 240-1
- JUNIPER MX 240-2
- JUNIPER MX 240-3

Traffic Sink

- ADVA NODE 1
- ADVA NODE 2
- ADVA NODE 3
- ADVA NODE 4

2 x 10 Gbps

Control Plane Connection

Data Plane Connection

iPOP2012, Kanagawa, Japan
Validation Testbed Addressing

172.16.1.70
172.16.1.71
172.16.1.72

Traffic Generator

192.168.8.3
192.168.8.2
192.168.8.1

Data Plane Connection
Control Plane Connection

172.16.1.34
172.16.1.36
172.16.1.38
172.16.1.40

Traffic Sink
Experiment description

• The network operator wants bandwidth for a new service.

• The NMS queries the PCE for the PATH.

• Two cases:
  – A) Enough resources at MPLS layer: MPLS PATH in the response
  – B) No resources at MPLS layer: Multilayer PATH

• In case of a Multilayer PATH, the NMS sends the VNTM a TE_LINK_SUGGESTION message.
  – The NMS extracts the part of the new TE-Link from the response

• The VNTM checks the policies.

• The VNTM accepts the suggestion and configures the WSON layer LSP using the UNI of the routers.
Validation Testbed
Message Exchange

1. NMS path request to ML-PCE
2. NMS request with ML-path to VNTM.
3. UNI request at source
4. UNI request and response at destination.
Message Exchange
Diagram of the Message Exchange
Example shows the Multilayer Case

VNTM (172.16.1.72)
- NMS begins PCEP session with MPLS PCE
- NMS sends 4 Gbps MPLSRequest
- PCC gets ML Path, Suggests VNTM the new TE link
- VNTM accepts suggestion, Completes UNI request with Interlayer TE Links (preconfigured) Configures router

NMS (172.16.1.71)
- Multilayer PCE starts PCEP handshake as soon as TCP connection is accepted
- MultiLayer PCE founds no available BW in MPLS layer. Computes Multilayer Path.

MULTILAYER PCE (172.16.1.70)
- Response (ERO: 192.168.8.3 /
SERVER_LAYER_INFO / 172.16.1.34:1 /
172.16.1.36:1 / 172.16.1.40 /
SERVER_LAYER_INFO / 192.168.8.1 /
- NMS sets ups MPLS service in source router (192.168.8.3)
Message Exchange

Message Exchange 1: NMS path request to ML-PCE (MPLS resources available case)

TCP Handshake initiated from NMS (172.16.1.71) to PCE (172.16.1.70)

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Length</th>
<th>Info</th>
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</thead>
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<td>PCEP</td>
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<td>PATH COMPUTATION REQUEST MESSAGE</td>
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<td>PCEP</td>
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<td>PCEP</td>
<td>70</td>
<td>KEEPALIVE MESSAGE</td>
</tr>
</tbody>
</table>

First PCEP Request

PCEP Handshake (OPEN + KA messages) between NMS (172.16.1.71) and PCE (172.16.1.70).
PCEP Messages are sent almost simultaneously

* CAPTURED AT PCE server (172.16.1.70)
Message Exchange

Message Exchange 1: Detailed PCEP Request
(MPLS resources available case)

* CAPTURED AT PCE server (172.16.1.70)
Message Exchange

Message Exchange 1: Detailed PCEP Response
(MPLS resources available case)

First PCEP Response: MPLS ONLY path, as resources are available at MPLS layer.

List of router IDs:

- ML-PCE
- NMS
- 1

* CAPTURED AT PCE server (172.16.1.70)
Message Exchange

Message Exchange 1: Detailed PCEP Response

Path Computation Element communication Protocol
PATH COMPUTATION REQUEST MESSAGE Header
RP object
END-POINT object
Object Class: END-POINT OBJECT (4)
Object Type: 1
Flags
Object Length: 12
Source IPv4 Address: 192.168.8.3
Destination IPv4 Address: 192.168.8.1
BANDWIDTH object
Object Class: BANDWIDTH OBJECT (5)
Object Type: 1
Flags
Object Length: 8
Bandwidth: 7,000000
OBJECTIVE FUNCTION object
Object Class: OBJECTIVE FUNCTION OBJECT (OF) (21)
Object Type: 1
Flags
Object Length: 8
OF-Code: Unknown (1100)

* CAPTURED AT PCE server (172.16.1.70)
Message Exchange
Message Exchange 2: Detailed PCEP Reply.
(NO resources available at MPLS layer)

Multilayer ERO from draft-ietf-pce-inter-layer-ext-05
Extensions to the Path Computation Element communication Protocol (PCEP) for Inter-Layer MPLS and GMPLS Traffic Engineering

* CAPTURED AT PCE server (172.16.1.70)
Message Exchange

Message Exchange 2: TE-Link suggestion

Two new messages proposed for the communication between to a VNTM:
- TE LINK SUGGESTION: Includes a PATH formed by the two MPLS endpoints and the lower layer Path
- TE LINK CONFIRMATION: Acknowledges the acceptance of a new TE-LINK suggestion

* CAPTURED AT VNTM (172.16.1.72)
Validation Testbed

Control Plane Configuration

Traffic Generator

192.168.8.3
20.20.20.2
20.20.20.1
172.16.1.34

192.168.8.2
172.16.1.38

192.168.8.1
41.41.41.2
41.41.41.1
172.16.1.40

Traffic Sink

172.16.1.36
UNI Request
RSVP Path at Source
Message Exchange

UNI Request: RSVP Path at destination

Traffic

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Length</th>
<th>Resource Reservation Protocol (RSVP)</th>
<th>Info</th>
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<td>2021</td>
<td>240,118,008</td>
<td>192.168.8.1</td>
<td>192.168.8.1</td>
<td>RSVP</td>
<td>408 Yes</td>
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<td>2023</td>
<td>241,930,266</td>
<td>192.168.8.1</td>
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<td>RSVP</td>
<td>112 Yes</td>
<td>HELLO Message</td>
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<td>192.168.8.1</td>
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<tr>
<td>2024</td>
<td>241,879,626</td>
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<td>2025</td>
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<td>192.168.8.1</td>
<td>RSVP</td>
<td>112 Yes</td>
<td>HELLO Message</td>
<td></td>
</tr>
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</table>

RRO IN PATH MESSAGE WITH UNNUMBERED INTERFACES IN LOWER LAYER
Message Exchange

UNI: RSVP Resv at destination

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Length</th>
<th>RSVP/Resv Protocol (RSVP)</th>
<th>Info</th>
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</thead>
<tbody>
<tr>
<td>2883</td>
<td>270.2432</td>
<td>192.168.8.1</td>
<td>192.167.201.1</td>
<td>RSVP</td>
<td>206</td>
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<tr>
<td>2860</td>
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<td>Yes</td>
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<td>2900</td>
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<td>RSVP</td>
<td>112</td>
<td>Yes</td>
<td>HELLO Message</td>
</tr>
</tbody>
</table>

Frame 2883: 206 bytes on wire (1654 bits), 206 bytes captured (1592 bits)

Juniper Ethernet


Generic Routing Encapsulation (GRE)


MPLS DESTINATION

Same Tunnel ID Than Path

MPLS SOURCE

192.168.8.1

Traffic Sink

172.16.1.36

41.41.41.1

41.41.41.2

172.16.1.40

192.168.8.1
Conclusions
Conclusions

• Multilayer PCE, VNTM and UNI can cooperate together
• They have proven to be feasible elements for the automatic operation of an overlay MPLS over WSON network.
• PCEP is a suitable protocol to communicate to the VNTM.
• The current standards need to be extended to suggest new configurations (e.g. new TE-Links) to the VNTM.
This work was supported by the ONE project in the FP7 Program, contract number INFSO-ICT-258300.

THANK YOU!!

QUESTIONS?