Architecture of dynamic VPNs in OpenFlow

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Observations

• Network Management Systems are growing in complexity

• VPNs used to share network resources and growing in numbers

⇒ complex network management

• Growing demand for application specific VPNs

• Leading to “Dynamic VPNs”
Dynamic VPNs

• Requirements:

  • All VPN features

  • Automated VPN creation, modification and deletion

  • Manage member ports

  • Adapt Paths to Network Resources and DVPN Requirements
Problem

• To implement DVPNs in the network:
  • Solve complexity of network management
  • Allow for granular control over network resources
Potential Solution

• OpenFlow and SDN

• Why the momentum?

• State of the art

• “Not supported”
Research Questions

• Can DVPNs be implemented using contemporary technologies?

• Can DVPNs be implemented using OpenFlow?

• What are the differences?
VPN Service

• Provider Provisioned VPN

• Layer 2 Ethernet broadcast domain

• Transparent to Customer

• No exchange of routing info between provider and customer
VPN Transport

- VPN “coloring”
- Ethernet frame encapsulation
VPN Transport

- Additional requirements for Carrier DVPN service:
  - MAC Scalability
  - Traffic Engineering (TE)
  - Load Sharing (ECMP)
  - Operations, Administration and Management (OAM)
  - Fast Failover
  - Rate Limiting of DVPN traffic
  - Rate Limiting of BUM traffic
DVPN Provisioning

• Base network to provide VPNs

• Install routes between PEs

• Automated VPN creation, modification and deletion:
  • Manage member ports
  • Adapt Paths to Network Resources and DVPN Requirements
MPLS Implementation

- MPLS with VPLS
  - Paths and VPN Coloring

- Protocol Stack Dependencies

- Complex configuration
  - Requires custom NMS
  - Lack of defined API

- Fast Failover using RSVP (another label)

- E-VPN MAC learning (draft)
MPLS Implementation

• Provisioning of DVPNs through NMS
  • Needs topology information to provide paths
  • Installs paths in RSVP, end-points in VPLS
OpenFlow Implementation

- SDN Architecture with OpenFlow 1.3
- Abstraction of the network
- Centralized Applications
  - MAC Learning
  - Traffic Engineering
  - ECMP
  - Fast Failover..
- MPLS labels
- Rate Limiting per Flow
OpenFlow Implementation

- Provisioning of DVPNs through Applications
  - Has topology information available
  - Traffic Engineering Application allows rerouting
  - Install Paths in all intermediate P’s
Research Answers

• Can DVPNs be implemented using contemporary technologies?
  • Yes, but management is complex and lacks control

• Can DVPNs be implemented using OpenFlow?
  • Yes, using MPLS labels and custom applications

• What are the differences?
## Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>MPLS</th>
<th>OpenFlow/SDN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tagging of VPN Traffic</td>
<td>VPLS</td>
<td>MPLS</td>
</tr>
<tr>
<td>MAC Scalability</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Topology Discovery</td>
<td>OSPF</td>
<td>centralized</td>
</tr>
<tr>
<td>Path Provisioning</td>
<td>RSVP / LDP</td>
<td>centralized</td>
</tr>
<tr>
<td>Traffic Engineering</td>
<td>RSVP</td>
<td>centralized</td>
</tr>
<tr>
<td>ECMP</td>
<td>yes</td>
<td>yes, using Groups</td>
</tr>
<tr>
<td>BUM limiting</td>
<td>dependent on HW</td>
<td>per flow</td>
</tr>
<tr>
<td>BUM traffic handling</td>
<td>flood</td>
<td>controller</td>
</tr>
<tr>
<td>Exchange C-MACs</td>
<td>E-VPN (draft)</td>
<td>centralized</td>
</tr>
<tr>
<td>Traffic Rate Limiting</td>
<td>dependent on HW</td>
<td>per flow</td>
</tr>
<tr>
<td>Fast Failover</td>
<td>FRR and BFD</td>
<td>yes, using Groups*</td>
</tr>
<tr>
<td>OAM</td>
<td>LSP Ping</td>
<td>centralized</td>
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## MPLS

<table>
<thead>
<tr>
<th>Pro’s</th>
<th>Con’s</th>
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<tbody>
<tr>
<td>• Known technology</td>
<td>• Large protocol stack</td>
</tr>
<tr>
<td></td>
<td>• No consistent management interface</td>
</tr>
<tr>
<td></td>
<td>• Complex NMS</td>
</tr>
<tr>
<td></td>
<td>• E-VPN in draft</td>
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</tbody>
</table>
OpenFlow

<table>
<thead>
<tr>
<th>Pro’s</th>
<th>Con’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Learn from MPLS</td>
<td>• No forwarding plane</td>
</tr>
<tr>
<td>• MAC Exchange on PEs</td>
<td>monitoring</td>
</tr>
<tr>
<td>• Rate Limiting per Flow</td>
<td>• No Northbound standard</td>
</tr>
<tr>
<td></td>
<td>• Reimplement intelligence</td>
</tr>
</tbody>
</table>
Conclusion

• MPLS lacks in manageability

• SDN architecture solves complexity

• OpenFlow missing essential carrier function
Questions?