OpenFlow Enlightenment
Extending lightpaths through the campus network

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Problem

User A

User B

Campus Network

Lightpath Entrance

Lightpath A

Lightpath B
OpenFlow

- Software defined networking.
- Dynamic programmable switching/routing.
- Forwarding based on various fields.
- Open interface to network hardware.
Research Question

Given the wide variety of campus networks, what solutions exist to provide end users with fast and easy access to lightpaths in a dynamic and secure way, using OpenFlow on Pica8 3290 switches?
Testbed

- 2x Pica8 3290 OpenFlow switches (with Open vSwitch)
- 2x Linux server
Generic Solution

Routing:

- Create ‘tunnel’ between switches over supported protocol.
Generic Solution (2)

Authorization:

- Use one field in header to provide access token.
- Check token on other side of tunnel.
- Update token every interval.
Scenario 1: Layer 2 Switched Network

Characteristics:

- Layer 2 path possible between end user and lightpath entrance (same VLAN).
- No IP routing involved.
- Headers above layer 2 remain unaltered.
Layer 2 Switched Network (2)

Solution: VLAN/MPLS.

- VLAN configured between OpenFlow switches.
- MPLS tag added with lightpath identifier.
- MPLS tag added with access token.
- Tunnel endpoint checks tags and forwards to appropriate lightpath.
Layer 2 Switched Network (3)

Solution: Q-in-Q (802.1ad).

- Architecture similar to MPLS solution.
- Lightpath ID and access token combined in inner VLAN tag.

Drawbacks:

- Campus network has to support Q-in-Q (uses other ethertype).
## Support

<table>
<thead>
<tr>
<th>Action</th>
<th>OpenFlow v1.2</th>
<th>Pica8 3290</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLAN push</td>
<td>Optional, suggested</td>
<td>Implemented</td>
</tr>
<tr>
<td>VLAN pop</td>
<td>Optional, suggested</td>
<td>Implemented</td>
</tr>
<tr>
<td>VLAN modify</td>
<td>Optional, suggested</td>
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</tr>
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<td>Optional</td>
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</tr>
<tr>
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<td>Optional</td>
<td>Implemented</td>
</tr>
<tr>
<td>Q-in-Q</td>
<td>Optional</td>
<td>Not implemented</td>
</tr>
</tbody>
</table>
Support (2)

- All necessary actions are optional in specifications.
- VLAN tag strip does not work as expected.
- MPLS tag push only works for the first packet in an IP/IPv6 flow.

Solutions cannot be implemented on Pica8 3290 with current firmware.
Scenario 2: MPLS Switched Network

Characteristics:

- MPLS label switched path (LSP) between end user and lightpath possible.
- No IP routing involved.
- Multiple MPLS labels can be pushed.
MPLS Switched Network (2)

Solution: more MPLS.

- MPLS LSPs configured between OpenFlow switches.
- MPLS tag added with lightpath identifier.
- MPLS tag added with access token.
- Tunnel endpoint checks tags and forwards to appropriate lightpath.

Drawbacks:

- Both OpenFlow switches need to participate in routing/label distribution protocols to set up LSP.
- Original ethernet header is stripped.
### Support

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Again:

- All necessary actions are optional in specifications.
- MPLS tag push only works for the first packet in an IP/IPv6 flow.

Solution cannot be implemented on Pica8 3290 with current firmware.
Scenario 3: IP Routed Network

Characteristics:
- No layer 2 path required between OpenFlow switches.
- Layer 2 and IP headers can be altered.
IP Routed Network (2)

Solution: Generic Routing Encapsulation (GRE).

- Set up GRE tunnel between both switches.
- Use GRE key field for lightpath ID and access token.

Drawbacks:

- Original ethernet header is stripped.
Support

OpenFlow v1.2 support:
- GRE is not included in OpenFlow specification.
- OpenFlow does allow ‘logical ports’ for tunnels.

Pica8 3290 support:
- GRE is supported.
- Only IP over GRE possible.
Conclusion

- Multiple solutions to lightpath problem are possible.
  - MPLS
  - Q-in-Q
  - GRE
- OpenFlow (optionally) supports most of those.
- Implementation on Pica8 3290 not yet mature.
Questions?