Experiments of GMPLS based layer2 path control functions for next generation wide area layer2 networks

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Agenda

✓ Introduction
✓ Architecture of NGL2 Network
✓ Extension of GMPLS for NGL2 Network
✓ Experimental Results
✓ Conclusions
Introduction

• Growth of Ethernet Technologies
  – Gigabit Ethernet (GE), 10GE, 40GE, 100GE
• Ethernet has been deployed surprisingly in Wide Area Network as well as Local Area Network (LAN).
• Wide Area Ethernet is focused on as a high performance carrier grade transport network.
Required Functions for Next Generation Layer2 Network

• Carrier Grade Ethernet
  = OAM enhancement + Protection

• Next generation layer2 network beyond Carrier Grade Ethernet requires:
  – Integration with Control Plane
  – Automatic Connection Setup Function
  – Quality of Service (QoS) guarantee
  – Rapid Protection / Restoration Functions
  – Backward Compatibility or Transparent Encapsulation for existing Ethernet
Our Approach for Next Generation Layer2

• GMPLS controlled Next Generation Layer2 (NGL2) network will be presented.
• Results of the experiment regarding with establishing a path in NGL2 network by the extended GMPLS.
• Achieve basic functions of
  – Automatic Connection Setup Function
  – Transparent Encapsulation for existing Ethernet
Architecture of GMPLS controlled NGL2 Network

- User domain (Ethernet)
- UNI
- Provider domain
- Core NGL2 Switch
- P-P NGL2 Path
- P-MP NGL2 Path
- User domain (Ethernet)
Data Transmission in NGL2 network

- A User MAC Frame is encapsulated into a NGL2 MAC Frame.
- A NGL2 path is set up by label switching technology.
  - NGL2 MAC Frames have Virtual Path Identifier (VPI).
  - Based on VPI, NGL2 MAC Frames are switched.
  - The NGL2 path is established automatically by GMPLS.
NGL2 MAC Frame Format

- Reuse the existing Ethernet technologies with minimum modification
- Designed to be almost same as the conventional Ethernet MAC frame format

User MAC Frame (IEEE 802.3D, 802.1Q, 802.1ad, 802.1ah)

<table>
<thead>
<tr>
<th>VPI</th>
<th>Type</th>
<th>VLAN</th>
<th>Data</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-DA</td>
<td>U-SA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Payload (Inner MAC Frame)

[Diagram showing fields: DA, SA, VPI, I-TAG, Type, Extend Header, TTL, Reserved, FCS]

VPI: Virtual Path Identifier
I-TAG: Service Instance Tag
U-DA: User Destination Address
U-SA: User Source Address
TTL: Time-To-Live
FCS: Frame Check Sequence
Swapping of VPI

- VPI is swapped link by link.
  - Ensure the scalability and simplify the management of establishing a NGL2 path by eliminating VLAN ID continuity constraint
  - Each Core NGL2 Switch has a VPI conversion table.
    - [In Port][ In VPI ][ Out Port ][ Out VPI]

- Swapping makes the management of VPIs complex.
  - Solve by using GMPLS as Control Plane
Extension of GMPLS for NGL2 Network

Two Main Challenges to establish NGL2 Path by GMPLS

1. The advertisement of Destination MAC address and Source MAC address of NGL2 frame
2. The dynamic configuration of VPI conversion tables

⇒ Extend GMPLS to achieve these two challenges
Advertisement of NGL2 MAC Addresses

- Create by using 32bit Node ID (Router ID) and 16bit Interface ID (Logical/Physical Port ID) of Control Plane.
  - OSPF-TE can advertise TE Link and Reachable Address.
  - Use Unnumbered Type (32 bit Router ID and 32 bit Interface ID)

- OSPF-TE doesn’t have to advertise 48 bit MAC addresses for NGL2 newly.
Dynamic Configuration of VPI Conversion Table

- Relate VPIs of NGL2 MAC frame to labels of GMPLS
  - Reserve labels = Assign VPIs
  - The value of labels are informed by Upstream Label Object.
  - The VPI conversion table is configured based on RESV message.
- By swapping, several VPIs are used on one NGL2 path.
  - No NGL2 switch know the VPIs assigned for the established path.
  ⇒ The values of assigned labels are written into Record Route Object (RRO) of RESV message.
  - Ingress Node can know the assigned VPIs.
Experimental Network Structure

- Use two Edge NGL2 Switches and one Core NGL2 Switch
  - Label Format: [Untag/Tagged][Port No.][VPI] ([Port No.] is not used.)
  - VPI = 3 (5.5.5.5 ⇔ 6.6.6.6), 1003 (6.6.6.6 ⇔ 7.7.7.7)
- Verify the establishment of NGL2 paths by the extended RSVP-TE
GMPLS controlled NGL2 Prototype System

• Control Plane (Host PC)
  – GMPLS Software (OSPF-TE / RSVP-TE)
  – **In-fiber In-band** Data Communication Network (DCN) provided by In-band Message Communication Channel (IMCC)

• Data Plane (PCI-X Board inserted in Host PC)
  – 1000Base-T Port × 2, FPGA (Frame Switch), DAPDNA* II chip × 2
  – MAC-in-MAC, IMCC, VLAN ID Swapping, FCS recalculation

* DAPDNA: Digital Application Processor / Distributed Network Architecture
Experimental Results (1/2)

- Establish/Tear a P-P NGL2 path between 5.5.5.5 and 7.7.7.7.
  - Data can be exchanged correctly between User PCs.
  - Max throughput: About 450 Mbps

- D-MAC \((07:07:07:07:00:4C)\) and S-MAC \((05:05:05:05:00:38)\) are set up by using Node IDs and IF IDs correctly

- The VPI conversion table \((0x0003 \leftrightarrow 0x03EB)\) of 6.6.6.6 is configured based on the values of assigned labels.
Experimental Results (2/2)

- The information of assigned labels is advertised correctly by using RRO of RESV message.
- Establish/Tear
  Several P-P NGL2 paths

Not yet implemented

- I-TAG
- P-MP NGL2 path
- QoS Control
- Link TE/Reachability Advertisement by OSPF-TE etc
Conclusions

- GMPLS controlled NGL2 is presented for realizing a next generation carrier grade layer2 network.
- RSVP-TE is extended for supporting the transport in NGL2.
- By experiment, it is confirmed that NGL2 switch prototype systems are configured, and a NGL2 path can be established dynamically and correctly.
Thank you!!

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