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Multi-chassis PON Protection in MPLS
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Abstract

While MPLS is deployed further and further to the access network, a converging network edge point which provides both MPLS and PON access capability appears. To provide resiliency for its services, multi-homing is needed to support PON access in MPLS. This document describes the multi-chassis PON protection architecture in MPLS and also proposes the ICCP extension to support it.

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1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Terminology

FTTx Fiber-to-the-x (FTTx, x = H for home, P for premises, C for curb)

ICCP Inter-Chassis Communication Protocol

OLT Optical Line Termination

ONU Optical Network Unit

MPLS Multi-Protocol Label Switching

PON Passive Optical Network

3. Introduction

MPLS is extending further and further to the edge of networks, for example, the seamless MPLS use cases as described in [SEAMLESS], and the MS-PW with PON access use case as described in [RFC6456], all show that MPLS is approaching the access networks.

Passive Optical Network (PON) can provide high bandwidth of 1Gbps or even 10Gbps, and provide support of access for dozens to more than one hundred subscribers at the same time. A huge number of PON access networks have been deployed over the last few years with the wide spread of FTTx technology.

With the fast growth of mobile data traffic, more and more LTE small cells and Wi-Fi hotspots will be deployed in the future. How to backhaul a large number of small cells or hotspots will pose a great challenge to mobile service providers.

PON access technology has the following advantages:

-saving trunk fibers with its point-to-multipoint physical topology;

-High bandwidth capability up to 10Gbps;

-Low Total Cost of Ownership (TCO).

PON also provides synchronization features, e.g., SyncE and IEEE1588 functionality, which can fulfill synchronization needs of mobile backhaul services. Some optical layer of protection mechanisms, such as Type B protection and Type C protection are also specified [G983.1] to avoid single point of failure in the access.

Therefore, PON may play a greater role in the access end for the mobile backhaul networks. Providing OLTs with MPLS functionality further facilitates multi-service convergence.

Type B protection architecture is an economical PON resiliency mechanism, where the working OLT and the working link between the working splitter and the working OLT (i.e., the working fiber) is protected by a redundant protection OLT and a redundant fiber between the working splitter and the protection OLT. This is different from the more complex and costly Type C protection architecture where working splitter and the working fibers from ONUs to the working splitter are further protected. Figure 1 demonstrates a typical scenario of Type B PON protection.

```
                        |                                 |
                        |<--Optical Distribution Network->|
                        |                                 |
                        |   branch               trunk    +-----+
                  +-----+   fibers               fibers   |     |
   Base     ------|     |     |                           . OLT |
   Stations ------| ONU |\    |                        ,''|  A  |
            ------|     |  \  V                     _-'   +-----+
                  +-----+    \                    .'
                            .  \  +----------+ ,-'
                  +-----+   .    \|          -'   Working
   Base     ------|     |   .     | Optical  |
   Stations ------| ONU |---------| Splitter |
            ------|     |   .    /|          -,   Protection
                  +-----+   .  /  +----------+ ''.,
                             /                     '-,    +-----+
                  +-----+  /                          ''.,|     |
   Base     ------|     |/                                | OLT |
   Stations ------| ONU |                                 |  B  |
            ------|     |                                 +-----+
                  +-----+
                Figure 1 Type B PON protection Architecture
```

Though the above PON architecture provides redundancy in its physical topology, some standard mechanisms are needed to exchange PON link status and network status between OLTs in a Redundancy Group (RG) so that protection and restoration can be done reliably, especially when the OLTs also support MPLS. Thus there is a need for Multi-chassis PON protection protocol in MPLS.

ICCP [ICCP] provides a framework for inter-chassis synchronization of state and configuration data between a set of two or more PEs. Currently ICCP only defines application specific messages for PW redundancy and mLACP, but it can be easily extended to support Type B PON as an Attachment Circuit (AC) redundancy.

This document proposes the extension of ICCP to support Multi-chassis PON protection in MPLS.

3.1. Multi-chassis PON Application TLVs

A set of multi-chassis PON application TLVs are defined in the following sub-sections.

3.1.1. PON Connect TLV

This TLV is included in the RG Connect message to signal the establishment of PON application connection.

```
 0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |U|F|   Type=0x00XX             |    Length                     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |      Protocol Version         |A|         Reserved            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                    Optional Sub-TLVs                          |
 ~                                                               ~
 |                                                               |
 +                                +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |             ...                |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- U and F Bits, both are set to 0.

- Type, set to 0x00XX for "PON Connect TLV".

- Length, Length of the TLV in octets excluding the U-bit, F-bit, Type, and Length fields.

- Protocol Version, the version of this PON specific protocol for the purposes of inter-chassis communication. This is set to 0x0001.

- A Bit, Acknowledgement Bit. Set to 1 if the sender has received a PON Connect TLV from the recipient. Otherwise, set to 0.

- Reserved, Reserved for future use.

- Optional Sub-TLVs, there are no optional Sub-TLVs defined for this version of the protocol.

3.1.2. PON Disconnect TLV

This TLV is included in the RG Disconnect message to indicate that the connection for the PON application is to be terminated.

```
 0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |U|F|   Type=0x00XX             |    Length                     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                       Optional Sub-TLVs                       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- U and F Bits, both are set to 0.

- Type, set to 0x00XX for "PON Disconnect TLV".

- Length, Length of the TLV in octets excluding the U-bit, F-bit, Type, and Length fields.

- Optional Sub-TLVs, there are no optional Sub-TLVs defined for this version of the protocol.

3.1.3. PON Configuration TLV

```
 0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |U|F|   Type=0x00XX             |    Length                     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                         System ID                             |
 +                               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                               |        System Priority        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |             Port ID           |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- U and F Bits, both are set to 0.

- Type, set to 0x00XX for "PON Configuration TLV".

- Length, Length of the TLV in octets excluding the U-bit, F-bit, Type, and Length fields.

- System ID, 6 octets encoding the System ID used by the OLT, which is a MAC address.

- System Priority, 2 octets encoding the System Priority.

- Port ID, 2 octets PON Port ID.

Further configuration considerations such as multicast table and ARP table for static MAC addresses will be added in a next version.

3.1.4.PON State TLV

```
 0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |U|F|   Type=0x00XX             |    Length                     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                              ROID                             |
 |                                                               |
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                    Local PON Port state                       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                   Remote PON Port state                       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- U and F Bits, both are set to 0.

- Type, set to 0x00XX for "PON State TLV"

- Length, Length of the TLV in octets excluding the U-bit, F-bit, Type, and Length fields.

- ROID, as defined in the ROID section of [ICCP].

- Local PON Port State, the status of the local PON port as determined by the sending OLT (PE). The last bit is defined as Fault indication of the PON Port associated with this PW.

- Remote PON Port State, the status of the remote PON port as determined by the remote peer of the sending OLT (PE). The last bit is defined as Fault indication of the PON Port associated with this PW.

4. Dual Homing protection procedures

Two typical MPLS protection network architectures for PON access are depicted in Fig.2 and Fig.3 (PON access segment is the same as in Fig.1 and thus omitted for simplification). OLTs with MPLS functionality are connected to a single PE (Fig.2) or dual home PEs (Fig.3) respectively, thus these devices constitute an MPLS network which provides PW transport services between ONUs and a CE.

```
                  +-----+
                  |     |
                  | OLT -,
                  |     | '.,
                  +-----+    ',
                              '',
                                 '.,     +-----+          +-----+
                                    ',  |     |          |     |
                                      '.  PE ------------  CE |
                                     .''|     |          |     |
                                  ,-'   +-----+          +-----+
                                .'
                  +-----+    .''
                  |     | ,-'
                  | OLT -'
                  |     |
                  +-----+
```

Figure 2 An MPLS network with a single PE

```
                  +-----+                +-----+
                  |     |                |     |
                  | OLT -----------------  PE -,
                  |     |                |     | ',
                  +-----+                +--/--+   ',
                                            |        '.
                                            |          '. +-----+
                                            |           ''     |
                                            |            |  CE |
                                            |            .     |
                                            |          ,'+-----+
                                            |       ,-'
                  +-----+                +--\--+  ,'
                  |     |                |     |.'
                  | OLT -----------------  PE -'
                  |     |                |     |
                  +-----+                +-----+
```

Figure 3 An MPLS network with dual home PEs

Faults may be encountered in PON access, or in the MPLS network (including the working OLT). Procedures for these cases are described in this section (it is assumed that both OLTs and PEs are working in independent mode of PW redundancy [RFC6870]).

4.1. Protection procedure upon PON interface failures

When a fault is detected on a working PON link, a working OLT MUST turn off its associated PON interface and MUST send an LDP notification message with a forward defect indication and with the Request Switchover bit being set to its peer PE on the remote end of the PW. At the same time, the working OLT MUST send an ICCP message with PON State TLV to notify the backup OLT of the PON fault. Upon receiving a PON state TLV where Local PON Port state is False, an OLT in the protection mode MUST activate the protection PON link in the protection group.

4.2. Protection procedure upon PW failures

Usually MPLS networks have its own protection mechanism such as LSP protection or Fast Reroute (FRR). But in a link sparse access or aggregation network where protection is impossible in LSP layer, the following PW layer protection procedures can be enabled.

When a fault is detected on its working PW (e.g., by VCCV BFD), a working OLT MUST turn off its associated PON interface and MUST send an ICCP message with PON State TLV to notify the backup OLT of the PON fault.

Upon receiving a PON state TLV where Local PON Port state is False, the backup OLT MUST activate its optical interface to the backup fiber. At the same time, the backup OLT MUST send a PW redundancy message to the remote PE, so that traffic can be switched to the backup PW.

4.3. Protection procedure upon the working OLT failure

If the backup OLT lost connection to the working OLT, it MUST activate its optical interface to the back fiber and activate the specific backup PW upon receiving a PW redundancy message from its remote PE with the Request Switchover bit being set, so that traffic can be reliably switched to the protection link and the backup PW.

5. Security Considerations

Security considerations as described in [ICCP] apply.

6. IANA Considerations

These values are requested from the registry of "ICC RG parameter type":

```
0x00X0         PON Connect TLV
0x00X1         PON Disconnect TLV
0x00X2         PON Configuration TLV
0x00X3         PON State TLV
```

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997

[RFC6870] Muley, P., Aissaoui, M., "Pseudowire Preferential Forwarding Status Bit", RFC 6870, February 2013

7.2. Informative References

[RFC6456] Li, H., Zheng, R., and Farrel, A., "Multi-Segment Pseudowires in Passive Optical Networks", RFC 6456, November 2011

[SEAMLESS] Leymann, N., and et al, "Seamless MPLS Architecture", draft-ietf-mpls-seamless-mpls-04, Work in progress

[ICCP] Martini, L. and et al, "Inter-Chassis Communication Protocol for L2VPN PE Redundancy", draft-ietf-pwe3-iccp-11, Work in progress

[G983.1] ITU-T, "Broadband optical access systems based on Passive Optical Networks (PON)", ITU-T G.983.1, January, 2005

8. Acknowledgments

TBD.

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