Multisegment Pseudowires in Passive Optical Networks
draft-li-pwe3-ms-pw-pon-00

Abstract

This draft describes MS-PW application in a PON network. Static configuration of one segment of PW is a typical case of MS-PW. When MS-PW is implemented in a PON network, the large quantity of T-PE makes such static provisioning a heavy burden of network manager. Making use of management protocol of GPON helps to reduce the labor of configuration, simplify and speedup the PW provision procedure to a great extent, and notify to switching PE (OLT) ACs status on T-PE (ONU). Link layer of GPON may also replace PSN to carry MPLS-PW.

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1. Introduction

RFC 5659 [RFC5659] defines the architecture for multi-segment pseudowires (MS-PWs) satisfying requirements in RFC 5254 [RFC5254]. Draft-ietf-pwe3-segmented-pw provides more detail on MS-PW. MS-PW is a typical technology for certain applications, e.g. mobile backhaul.

Among all technologies in access and metro networks, Passive Optical Network (PON) provides longer distance, higher bandwidth with better economy than other technologies like point-to-point Ethernet or DSL in many scenarios. Mobile backhaul with PON network is already at its dawn.

In a PON network, the ONU and OLT are adjacent nodes connected by Optical Distribution Network (ODN), which consists of optical fibers and optical splitters in a tree topology. Link between each ONU and OLT is simulated as point to point, and there is no redundant path between them. OLT resides in the central office, while ONUs reside in customer premises. ONUs are deployed with a huge number and cost sensitive.

In a mobile backhaul network, many 2G and 3G base stations still use legacy interfaces like TDM and ATM. Therefore, PWs has to start from devices directly connected with base stations. In the case of mobile backhauling with PON, ONUs connected with bases stations are T-PEs, while OLT is the switching point. Routing protocols and dynamic labels allocation protocols like LDP will extremely increase ONUs’ cost. As there is no redundant link between each ONU and the OLT, routing and path selection are not necessary between the ONUs and the OLT. This will greatly reduce the cost of an ONU when it acts as a PW PE node. Therefore, static provision of PW labels between ONUs and the OLT is preferred. However, if provision PW labels on ONUs by Network Management System directly requires a network manager touch each ONU one by one, which brings a large amount of OPEX.

According to ITU-T G.984.4amd2 [G.984.4amd2] and G.988 [G.988], the management protocol of GPON can also configure variant PWs on ONU. This provides a cost-saving method of static provisioning of PW in a GPON network. MPLS-PW may be either carried by PSNs as defined in RFC5659 [RFC5659], or by GPON link layer according to ITU-T G.984.3amd1 [G.984.3amd1].

2. Specification of Requirements

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 RFC 2119 [RFC2119].
3. Terminology

The terminology specified in RFC3985 [RFC3985] and RFC5659 [RFC5659] applies. In addition, we defined the following terms related with PON according to ITU-T G.984.1 [G.984.1]:

- **Gigabit Passive Optical Network (GPON):** A variant of the Passive Optical Network (PON) access technology supporting transmission rates in excess of 1Gbps and based on the ITU-T G.984 series of Recommendations.

- **GPON Transmission Convergence (GTC) layer:** A protocol layer of the GPON protocol suite that is positioned between the Physical Media Dependent (PMD) layer and the G-PON clients. The GTC layer is composed of GTC Framing sublayer and GTC Adaptation sublayer.

- **GPON Encapsulation Method (GEM):** A data frame transport scheme used in GPON systems that is connection-oriented and that supports fragmentation of the user data frames into variable sized transmission fragments.

- **GEM Port:** An abstraction on the GTC adaptation sublayer representing a logical connection associated with a specific client packet flow.

- **Optical distribution network (ODN):** In the PON context, a tree of optical fibers in the access network, supplemented with power or wavelength splitters, filters, or other passive optical devices.

- **Optical Line Termination (OLT):** A device that terminates the common (root) endpoint of an ODN, implements a PON protocol, such as that defined by ITU-T G.984 series, and adapts PON PDUs for uplink communications over the provider service interface. The OLT provides management and maintenance functions for the subtended ODN and ONUs. In this draft, OLT is actually a network element with multiple PON ports and uplinks.

- **Optical Network Termination (ONT):** A single subscriber device that terminates any one of the distributed (leaf) endpoints of an ODN, implements a PON protocol, and adapts PON PDUs to subscriber service interfaces. An ONT is a special case of an ONU.

- **Optical Network Unit (ONU):** A generic term denoting a device that terminates any one of the distributed (leaf) endpoints of an ODN, implements a PON protocol, and adapts PON PDUs to subscriber service interfaces. In some contexts, an ONU implies a multiple subscriber device.
ONT management and control interface (OMCI). The management and control channel between OLT and ONT in PON network. The OMCI protocol runs across a GEM connection between the OLT Controller and the ONT Controller that is established at ONT initialization. The OMCI protocol is asymmetric: the Controller in the OLT is the master and the one in the ONT is the slave. A single OLT Controller using multiple instances of the protocol over separate control channels may control multiple ONTs. The OMCI protocol is used to manage the ONT in areas of configuration, fault, performance and security.

PON Network. An OLT connected using an ODN to one or more ONUs or ONTs.

4. Multi-Segment Pseudowire over PON Network Reference Model

RFC5659 [RFC5659] provides several pseudowire emulation edge-to-edge (PWE3) reference architectures for the multi-segment case, which are general models extended from RFC3985 [RFC3985] to enable point-to-point pseudowires through multiple PSN tunnels.

A GPON network consists of an Optical Line Termination (OLT), an Optical Distribution Network (ODN) and multiple Optical Network Units (ONU). The ODN is actually a fiber tree that provides physical connections between the OLT and the ONUs. GPON has its own physical layer and link layer. GEM Port is a logical point-to-point connection between the OLT and each ONU over GPON Transmission Convergence (GTC) layer. There could be more than one GEM port between the OLT and an ONU. Each GEM port could be assigned different QoS and bandwidth.
Network is partitioned into access segments and Metro/Core segments with the hub & spoke topology.

MS-PW is recommended when extending PW technology to access nodes. This removes the need of full mesh. It minimizes the number of PSN tunnel and signaling adjacencies terminating on access nodes and reduces the routing information processed by access nodes. Thus it can enhance the scalability and lower the complexity. The OLT is recommended as a S-PE to enable PW over GPON such that IP/MPLS functionality can be optimized within each segments.

Figure A applies the MS-PW architecture in a PON network and shows the specific technologies usages. The Terminating PE1 (T-PE1) is an Optical Network Unit (ONU), while Switching PE1 (S-PE1) is an Optical Line Termination (OLT). GEM ports replace PSN tunnels between ONU (T-PE1) and OLT (S-PE1) across Optical Distribution Network (ODN), and a PSN tunnel extends from S-PE1 to T-PE2 across PSN.

In a PON network, the ONUs and the OLT are adjacent nodes connected by Optical Distribution Network (ODN), which consists of optical fibers and optical splitters in a tree topology. Routing or path selection is unnecessary, as there is only one unique path between each ONU and the OLT.

5. MS-PW in PON for Mobile Backhaul

As stated in RFC5254 [RFC5254], when a TDM access network is replaced
with a packet-based infrastructure, initiating PWs closer to the end-user and converging multiple services onto a single access network may reduce expenses. Backhauling 2G Base Stations (BS) by a packet network is a typical use case that may benefit from moving pseudowire PEs closer to the end-user and requires pseudowires to be extended into the access network. In case the access network is a PON, pseudowires are expected to extend to Optical Network Units (ONUs). Mobile services are backhauled from base stations all the way back to a mobile network Controller via pseudowires. PEs are attached by base stations and the Controller on both ends respectively. This means each ONU acts as an edge PE that terminates attachment circuits (ACs) from base stations, and encapsulates native data in them to pseudowires.

MS-PW is particularly preferred in this case according to RFC5659 [RFC5659], as an edge PE (connected to the Controller) terminates N PWs to/from N different remote PEs (connected to base stations), which attach to a single intermediate PE. The intermediate PE switches PWs in the network depicted in figure A, CE1 is the base station and CE2 is the controller. ONUs are PW Terminating Provider Edge (T-PE) where Access Circuits are attached, while OLT is the PW Switching Provider Edge (S-PE).

PON is a network with a tree topology that fits the infrastructure described above. The OLT aggregates a large number of ONUs, which terminate ACs from base stations. For economic reasons, ONUs are built to be low cost and without powerful routing or IP capabilities. The cost of ONUs will evidently increase if they are required to support similar PW setup and maintenance mechanisms as that used in the core network. Multi-segment PW enables PW in PON network to use a different setup mechanism than that in the metro and core network, with the OLT performing an intermediate PE switching PWs between ONUs and the Controller. For example, the core could use a dynamic control plane (T-LDP PWs over RSVP-TE tunnels), while the access network could be provisioned through the management plane using the Network Management Station.

6. Label Provisioning for Pseudowires over PON

In a PON network with MS-PW, where OLT acts as a switching point and ONU as a PE, provision of PWs between OLT and ONU may be performed through static configuration, e.g. from a NMS. However, it incurs heavy burden of management if each ONU has to be touched to set up PW from ONUs to OLT and configure forwarding information on ONUs. The huge number of ONUs makes this method quite forbidding.

Using a management protocol over PON to provision pseudowire labels
on ONUs largely reduces labor of static label configuration, while keeping simplicity of ONU by not implementing a dynamic control plane.

Thanks to the management protocol in GPON system, ONT management and control interface (OMCI), a semi-static mechanism could be used to set up PWs from ONUs to OLT. OMCI, running between the OLT and the ONUs, is the channel that OLT manages and controls ONUs. All GPON physical layer and data GTC layer configuration on ONUs are installed via OMCI. It also has the capability to configure MPLS-PW labels and related forwarding information on ONUs per ITU-T G.984.4amd2 [G.984.4amd2] and G.988 [G.988]. When using OMCI to provision PWs on ONU, the network manager only needs to send all configurations to the OLT, which will send all parameters to ONUs automatically through OMCI. There is no need to touch each ONU.

OMCI now supports configuration of variant types of PWs, e.g. TDM, ATM and Ethernet. Besides, OMCI can act as a signaling mechanism between ONU and OLT, which enables the ONU to notify AC status to OLT.

7. MPLS-PW Switching in PON network

Expanding PW to the ONU requires some form of routing hierarchy. The approach taken here is to divide the network into access segments and Metro/Core segments. The OLT is the interconnecting point of Hub and Spokes. PSNs or GPON in the access segment are spoke tunnels, while PSNs in the core segment are hub tunnels.

MPLS-PW in a PON network may use full PSN encapsulation by ignoring PON GTC layer. According to ITU-T G.984.3amd1 [G.984.3amd1], MPLS-PW can be carried by GEM Port. That is, in a GPON network, PSN of MPLS-PWs can be replaced by GEM Port.

```
+------------+   +------------+
 PW          PW
+------------+   +------------+
 GEM         MPLS
+------------+   +------------+
 GPON-PHY    Link layer
+------------+   +------------+
      PHY
```

Figure B illustrates protocol stacks on the OLT when GEM Port replaces PSN for MPLS-PW over GPON. MPLS label for PSN is replaced by GEM Port ID.
Multiple GEM Ports are supported for each pair of OLT and ONU, which enables multiple PSNs for each ONU. According to current GPON system specification, one GPON port supports maximum 4096 GEM Ports shared by all ONUs connected to it. One GPON port can aggregate maximum 64 ONUs, but typically no more than 8 ONUs for bandwidth reason, when the ONU is a Multi-Dwelling Unit (MDU) or a Multi-Tenant Unit (MTU) that serves multiple subscribers. There should be no scalability problem for GEM Ports to carry MPLS-PWs between ONU and OLT.

8. IANA Considerations

No new options or messages are defined in this document.

9. Security Considerations

GPON has its own security mechanism to guarantee each ONU are isolated on GPON link layer. There is no other security issues concerned.

10. References

10.1. Normative References


[RFC5254] "Requirements for Multi-Segment Pseudowire Emulation Edge-to-Edge (PWE3)", N. Bitar, M. Bocci, L. Martini, RFC5254, October 2008


10.2. Informative References

[G.988] ITU-T, "ONU management and control interface (OMCI) specification"

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