Internet Engineering Task Force (IETF)
Request for Comments: 7167
Category: Informational
ISSN: 2070-1721

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April 2014

A Framework for Point-to-Multipoint MPLS in Transport Networks

Abstract

The Multiprotocol Label Switching Transport Profile (MPLS-TP) is the common set of MPLS protocol functions defined to enable the construction and operation of packet transport networks. The MPLS-TP supports both point-to-point and point-to-multipoint transport paths. This document defines the elements and functions of the MPLS-TP architecture that are applicable specifically to supporting point-to-multipoint transport paths.

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1. Introduction

The Multiprotocol Label Switching Transport Profile (MPLS-TP) is the common set of MPLS protocol functions defined to meet the requirements specified in [RFC5654]. The MPLS-TP Framework [RFC5921] provides an overall introduction to the MPLS-TP and defines the general architecture of the Transport Profile, as well as the aspects specific to point-to-point transport paths. The purpose of this document is to define the elements and functions of the MPLS-TP architecture applicable specifically to supporting point-to-multipoint transport paths.

1.1. Scope

This document defines the elements and functions of the MPLS-TP architecture related to supporting point-to-multipoint transport paths. The reader is referred to [RFC5921] for the aspects of the MPLS-TP architecture that are generic or are concerned specifically with point-to-point transport paths.

1.2. Terminology

Term	Definition
CE	Customer Edge
LSP	Label Switched Path
LSR	Label Switching Router
MEG	Maintenance Entity Group
MEP	Maintenance Entity Group End Point
MIP	Maintenance Entity Group Intermediate Point
MPLS-TE	MPLS Traffic Engineering
MPLS-TP	MPLS Transport Profile
OAM	Operations, Administration, and Maintenance
OTN	Optical Transport Network
P2MP	Point-to-multipoint
PW	Pseudowire
RSVP-TE	Resource Reservation Protocol - Traffic Engineering
SDH	Synchronous Digital Hierarchy
tLDP	Targeted LDP

Detailed definitions and additional terminology may be found in [RFC5921] and [RFC5654].

2. Applicability

The point-to-multipoint connectivity provided by an MPLS-TP network is based on the point-to-multipoint connectivity provided by MPLS networks. Traffic Engineered P2MP LSP support is discussed in [RFC4875] and [RFC5332], and P2MP PW support is being developed based on [P2MP-PW-REQS] and [VPMS-FRMWK-REQS]. MPLS-TP point-to-multipoint connectivity is analogous to that provided by traditional transport technologies such as Optical Transport Network point-to-multipoint [G.798] and drop-and-continue [G.780], and thus supports the same class of traditional applications, e.g., video distribution.

The scope of this document is limited to point-to-multipoint functions and it does not discuss multipoint-to-multipoint support.

3. MPLS-TP P2MP Requirements

The requirements for MPLS-TP are specified in [RFC5654], [RFC5860], and [RFC5951]. This section provides a brief summary of point-to-multipoint transport requirements as set out in those documents; the reader is referred to the documents themselves for the definitive and complete list of requirements. This summary does not include the RFC 2119 [BCP14] conformance language used in the original documents as this document is not authoritative.

From [RFC5654]:

- MPLS-TP must support traffic-engineered point-to-multipoint transport paths.

- MPLS-TP must support unidirectional point-to-multipoint transport paths.

- MPLS-TP must be capable of using P2MP server (sub)layer capabilities as well as P2P server (sub)layer capabilities when supporting P2MP MPLS-TP transport paths.

- The MPLS-TP control plane must support establishing all the connectivity patterns defined for the MPLS-TP data plane (i.e., unidirectional P2P, associated bidirectional P2P, co-routed bidirectional P2P, unidirectional P2MP) including configuration of protection functions and any associated maintenance functions.

- Recovery techniques used for P2P and P2MP should be identical to simplify implementation and operation.

- Unidirectional 1+1 and 1:n protection for P2MP connectivity must be supported.

- o MPLS-TP recovery in a ring must protect unidirectional P2MP transport paths.

From [RFC5860]:

- o The protocol solution(s) developed to perform the following OAM functions must also apply to point-to-point associated bidirectional LSPs, point-to-point unidirectional LSPs, and point-to-multipoint LSPs:

  * Continuity Check
  * Connectivity Verification, proactive
  * Lock Instruct
  * Lock Reporting
  * Alarm Reporting
  * Client Failure Indication
  * Packet Loss Measurement
  * Packet Delay Measurement

- o The protocol solution(s) developed to perform the following OAM functions may also apply to point-to-point associated bidirectional LSPs, point-to-point unidirectional LSPs, and point-to-multipoint LSPs:

  * Connectivity Verification, on-demand
  * Route Tracing
  * Diagnostic Tests
  * Remote Defect Indication

From [RFC5951]:

- o For unidirectional (P2P and point-to-multipoint (P2MP)) connection, proactive measurement of packet loss and loss ratio is required.

- o For a unidirectional (P2P and P2MP) connection, on-demand measurement of delay measurement is required.

4. Architecture

The overall architecture of the MPLS-TP is defined in [RFC5921]. The architecture for point-to-multipoint MPLS-TP comprises the following additional elements and functions:

- o Unidirectional point-to-multipoint LSPs
- o Unidirectional point-to-multipoint PWs
- o Optional point-to-multipoint LSP and PW control planes
- o Survivability, network management, and Operations, Administration, and Maintenance functions for point-to-multipoint PWs and LSPs.

The following subsection summarises the encapsulation and forwarding of point-to-multipoint traffic within an MPLS-TP network, and the encapsulation options for delivery of traffic to and from MPLS-TP CE devices when the network is providing a packet transport service.

4.1. MPLS-TP Encapsulation and Forwarding

Packet encapsulation and forwarding for MPLS-TP point-to-multipoint LSPs is identical to that for MPLS-TE point-to-multipoint LSPs. MPLS-TE point-to-multipoint LSPs were introduced in [RFC4875] and the related data-plane behaviour was further clarified in [RFC5332]. MPLS-TP allows for both upstream-assigned and downstream-assigned labels for use with point-to-multipoint LSPs.

Packet encapsulation and forwarding for point-to-multipoint PWs has been discussed within the PWE3 Working Group [P2MP-PW-ENCAPS], but such definition is for further study.

5. Operations, Administration, and Maintenance

The requirements for MPLS-TP OAM are specified in [RFC5860]. The overall OAM architecture for MPLS-TP is defined in [RFC6371], and P2MP OAM design considerations are described in Section 3.7 of that RFC.

All the traffic sent over a P2MP transport path, including OAM packets generated by a MEP, is sent (multicast) from the root towards all the leaves, and thus may be processed by all the MIPs and MEPs associated with a P2MP MEG. If an OAM packet is to be processed by only a specific leaf, it requires information to indicate to all other leaves that the packet must be discarded. To address a packet to an intermediate node in the tree, Time-to-Live-based addressing is used to set the radius and additional information in the OAM payload is used to identify the specific destination. It is worth noting that a MIP and MEP may be instantiated on a single node when it is both a branch and leaf node.

P2MP paths are unidirectional; therefore, any return path to an originating MEP for on-demand transactions will be out of band. Out-of-band return paths are discussed in Section 3.8 of [RFC5921].

A more detailed discussion of P2MP OAM considerations can be found in [MPLS-TP-P2MP-OAM].

6. Control Plane

The framework for the MPLS-TP control plane is provided in [RFC6373]. This document reviews MPLS-TP control-plane requirements as well as provides details on how the MPLS-TP control plane satisfies these requirements. Most of the requirements identified in [RFC6373] apply equally to P2P and P2MP transport paths. The key P2MP-specific control-plane requirements are:

- requirement 6 (P2MP transport paths),
- requirement 34 (use P2P sub-layers),
- requirement 49 (common recovery solutions for P2P and P2MP),
- requirement 59 (1+1 protection),
- requirement 62 (1:n protection), and
- requirement 65 (1:n shared mesh recovery).

[RFC6373] defines the control-plane approach used to support MPLS-TP transport paths. It identifies GMPLS as the control plane for MPLS-TP LSPs and tLDP as the control plane for PWs. MPLS-TP allows that either, or both, LSPs and PWs to be provisioned statically or via a control plane. Quoting from [RFC6373]:

> The PW and LSP control planes, collectively, must satisfy the MPLS-TP control-plane requirements. As with P2P services, when P2MP client services are provided directly via LSPs, all requirements must be satisfied by the LSP control plane. When client services are provided via PWs, the PW and LSP control planes can operate in combination, and some functions may be satisfied via the PW control plane while others are provided to PWs by the LSP control plane. This is particularly noteworthy for P2MP recovery.

6.1. P2MP LSP Control Plane

The MPLS-TP control plane for P2MP LSPs uses GMPLS and is based on RSVP-TE for P2MP LSPs as defined in [RFC4875]. A detailed listing of how GMPLS satisfies MPLS-TP control-plane requirements is provided in [RFC6373].

[RFC6373] notes that recovery techniques for traffic engineered P2MP LSPs are not formally defined, and that such a definition is needed. A formal definition will be based on existing RFCs and may not require any new protocol mechanisms but, nonetheless, should be documented. GMPLS recovery is defined in [RFC4872] and [RFC4873]. Protection of P2MP LSPs is also discussed in [RFC6372] Section 4.7.3.

6.2. P2MP PW Control Plane

The MPLS-TP control plane for P2MP PWs should be based on the LDP control protocol used for point-to-point PWs [RFC4447], with updates as required for P2MP applications. A detailed specification of the control plane for P2MP PWs is for further study.

7. Survivability

The overall survivability architecture for MPLS-TP is defined in [RFC6372], and Section 4.7.3 of that RFC in particular describes the application of linear protection to unidirectional P2MP entities using 1+1 and 1:1 protection architecture. For 1+1, the approach is for the root of the P2MP tree to bridge the user traffic to both the working and protection entities. Each sink/leaf MPLS-TP node selects the traffic from one entity according to some predetermined criteria. For 1:1, the source/root MPLS-TP node needs to identify the existence of a fault condition impacting delivery to any of the leaves. Fault notification happens from the node identifying the fault to the root node via an out-of-band path. The root then selects the protection transport path for traffic transfer. More sophisticated survivability approaches such as partial tree protection and 1:n protection are for further study.

The IETF has no experience with P2MP PW survivability as yet; therefore, it is proposed that the P2MP PW survivability will initially rely on the LSP survivability. Further work is needed on this subject, particularly if a requirement emerges to provide survivability for P2MP PWs in an MPLS-TP context.

8. Network Management

An overview of network management considerations for MPLS-TP can be found in Section 3.14 of [RFC5921]. The provided description applies equally to P2MP transport paths.

The network management architecture and requirements for MPLS-TP are specified in [RFC5951]. They derive from the generic specifications described in ITU-T G.7710/Y.1701 [G.7710] for transport technologies. They also incorporate the OAM requirements for MPLS networks [RFC4377] and MPLS-TP networks [RFC5860] and expand on those requirements to cover the modifications necessary for fault, configuration, performance, and security in a transport network. [RFC5951] covers all MPLS-TP connection types, including P2MP.

[RFC6639] provides the MIB-based architecture for MPLS-TP. It reviews the interrelationships between different MIB modules that are not MPLS-TP specific and that can be leveraged for MPLS-TP network management, and identifies areas where additional MIB modules are required. While the document does not consider P2MP transport paths, it does provide a foundation for an analysis of areas where MIB-module modification and addition may be needed to fully support P2MP transport paths. There has also been work in the MPLS working group on a P2MP specific MIB, [MPLS-TE-P2MP-MIB].

9. Security Considerations

General security considerations for MPLS-TP are covered in [RFC5921]. Additional security considerations for P2MP LSPs are provided in [RFC4875]. This document introduces no new security considerations beyond those covered in those documents.

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