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Q. Zhao
E. Chen
Huawei Technology
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Protection Mechanisms for Label Distribution Protocol P2MP/MP2MP Label Switched Paths
draft-zhao-mpls-mldp-protections-01.txt

Abstract

Service providers continue to deploy real-time multicast applications using Multicast LDP (mLDP) across MPLS networks. There is a clear need to protect these real-time applications and to provide the shortest switching times in the event of failure. This document outlines the requirements, describes the protection mechanisms available, and where necessary proposes extensions to facilitate mLDP P2MP and MP2MP LSP protection within an MPLS network.

Table of Contents

1. Terminology

For a clear narrative, this section gives a general conceptional overview of the terms.

- PLR: The node where the traffic is logically redirected onto the preset backup path is called Point of Local Repair.

- MP: The node where the backup path merges with the primary path is called Merge Point.

- FD: The node that detects the failure on primary path, and then triggers the action(s) for traffic protection is called Failure Detector. Either traffic sender or receiver can be the FD, depending on which protection mode are deployed. More details are described in later sections of this document.

- SP: The node where the traffic is physically switched/duplicated onto the backup path is called Switchover Point. In multicast cases, PLR and SP can be two different nodes. More details are described in later sections of this document.

2. Requirement Language

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. Introduction

In order to meet user demands, operators and service providers continue to deploy multicast applications using mLDP across MPLS networks. In certain scenarios, traditional IGP-mLDP convergence mechanisms fail to meet protection switching times required to minimise, or negate entirely, application interruptions for real-time applications, including stock trading, on-line games, and multimedia teleconferencing.

Current best practice for protecting services, and higher applications includes the pre-computation and establishment of a backup path, this can decrease the convergence time efficiently. Once a failure has been detected on the primary path, the traffic should be transmitted across the back-up path.

However, two major challenges exist with the aforementioned solution. The first is how to build an absolutely disjointed backup path for

each node in a multicast tree; the second is how to balance between convergence time and resource consumption.

This document provides several ways to setup the backup path for mLDP LSP, including P2P tunnel based mLDP local protection, P2MP LSP based mLDP local protection, and end-to-end protection. The goal is to build a reliable umbrella to against traffic black hole. Note that the buackup path computation is out of the scope of this draft, the algorothm can be either LFA or any other algorithms available including the offline tools. Besides, how to detect failure is also outside the scope of this document.

More and more users are apt to deploy multicast applications on MPLS mLDP network. In some scenarios, traditional IGP-mLDP convergence is hard to meet the requirements of those real-time applications, such as stock business, on-line game, and multimedia teleconference.

The industry has reached a consensus that setting up a backup path previously can decrease the convergence time efficiently. No matter how the above-mentioned backup path was established, once the failure is detected, the traffic should be transmitted at that path as soon as possible. Even so, there are still two major challenges left for

us, one is how to build an absolutely disjointed backup path for each node in a multicast tree; the other is how to balance between convergence time and resource consumption.

It is getting urgent to find the ideal protection mechanism(s) to improve the convergence time, and at the meantime minimize the side-effects, such as bandwidth wastage.

For a primary LDP P2MP/MP2MP LSP, there are several ways to set up its backup path. It can use RSVP-TE P2P tunnel as a logical out-going interface, consequently utilize the mature high availability technologies of RSVP-TE. Or, it can make use of LDP P2P backup LSP as a packet encapsulation, so that the complex configuration of P2P RSVP-TE can be skipped. Or, it can build its own P2MP/MP2MP backup LSP according to IGP's loop-free alternative route, thus avoid unnecessary packet duplication. Other than these, it can also build a totally disjointed LSP in another topology, accordingly take advantage of the real end-to-end protection.

When the backup path is present, there are two options for packet forwarding and switchover. If the traffic sender feeds the stream on both paths, and the traffic receiver drops packet on backup path, the switchover will be very quick once the failure is detected, because the whole switchover action is a local behavior on traffic receiver. The disadvantage of this manner is that traffic will be duplicated on both paths, and consume double bandwidth. Contrastively, if the

traffic sender feeds stream only on the primary path, the resource wastage can be waived. Cooperation is needed in this manner, so there will be some protocol extensions. But if the performance can be equal or better than the previous option, it is reasonable to choose the second one.

This document describes several methods to setup and switch paths for options to setup the backup LDP P2MP/MP2MP LSP. mLDP LSPs, including local protection, territorial protection, and end-to-end protection. The goal is to identify strengths, weaknesses and gaps, in order to build a reliable set of tools to shield against traffic black holes that would severely impact real-time applications, in the event of primary path failure.

3.1. Requirements

A number of requirements have been identified that allow the optimal set of mechanisms to developed. These currently include:

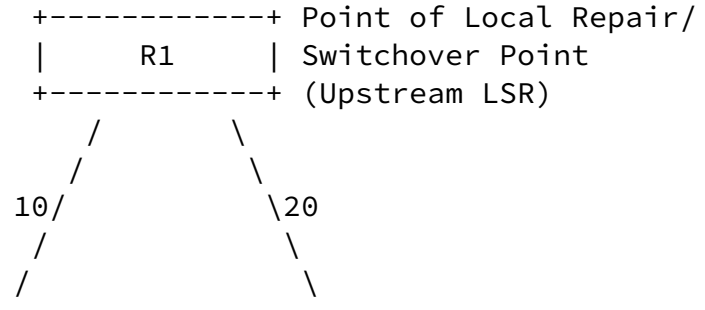
- Computation of a disjointed (link and node) backup path within the multicast tree;
- Minimisation of protection convergence time;
- Optimisation of bandwidth usage.

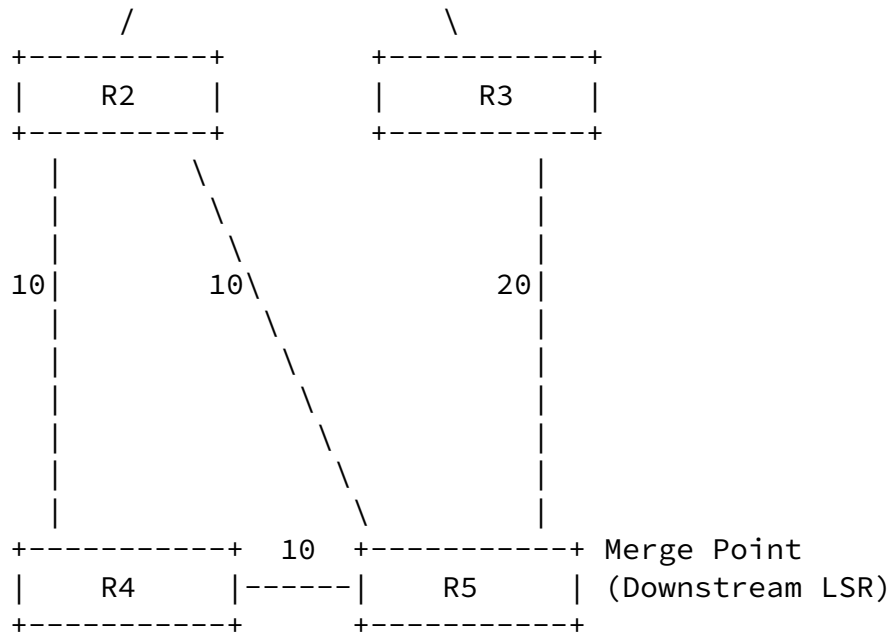
3.2. Scope

The method to detect failure is outside the scope of this document. Also this document does not provide any authorization mechanism for controlling the set of LSRs that may attempt to join a mLDP protection session.

4. mLDP Local Protection using P2P LSP

By encapsulating mLDP packets within an P2P TE tunnel or P2P LDP backup LSP, the LDP P2MP/MP2MP LSP can be protected by the P2P protection mechanisms. However, this protection mechanism is not capable of detecting, and recovering, if the failure occurs on the destination node of the P2P backup LSP. Thus, this section provides a unified method to protect both node and link with P2P backup LSP.





mLDP Local Protection using P2P LSP

Figure 1

In Figure 1 (P2P Based mLDP Local Protection Example) above, the preferential path from R1 to R4/R5 is through R2, and the secondary path is through R3. In this case, the mLDP LSP will be established according to the IGP preferential path as R1--R2--R4/R5.

It is the responsibility of R2 to inform R1 of its downstream LSRs (in this example R4 and R5) and the respective labels (L4 and L5). Once the link between R1 and R2 fails, or R2 node fails, R1 will duplicate the traffic to R4 and R5, with inner label as L4/L5, and outer label as the P2P backup LSP R1--R3--R5--R4 and R1--R3--R5.

Finally, the previous forwarding states will be removed after R4 and R5 finish their Make-Before-Break (MBB) procedure.

Note that the mLDP Local Protection mechanism can be used in any part of the mLDP LSP other then the ingress and egress nodes. In other words, R1 can be either Ingress or Transit node, R4/R5 can be either

Transit or Egress node. Only R1 and R2 need enhancement for this

mechanism, other nodes can just follow the existing mature protocol procedures.

4.1. Signaling procedures for P2P Based Local Protection

Continuing to use Figure 1 (mLDP Local Protection Example), R2 sends a notification message to R1 to inform the node that R2 has two downstream nodes, R4 and R5 with forwarding labels L4 and L5 respectively.

When R1 sees R2 node going down, it takes mLDP packets as it would send them to R4 and R5 through R2 and sends them into the two P2P backup tunnels:

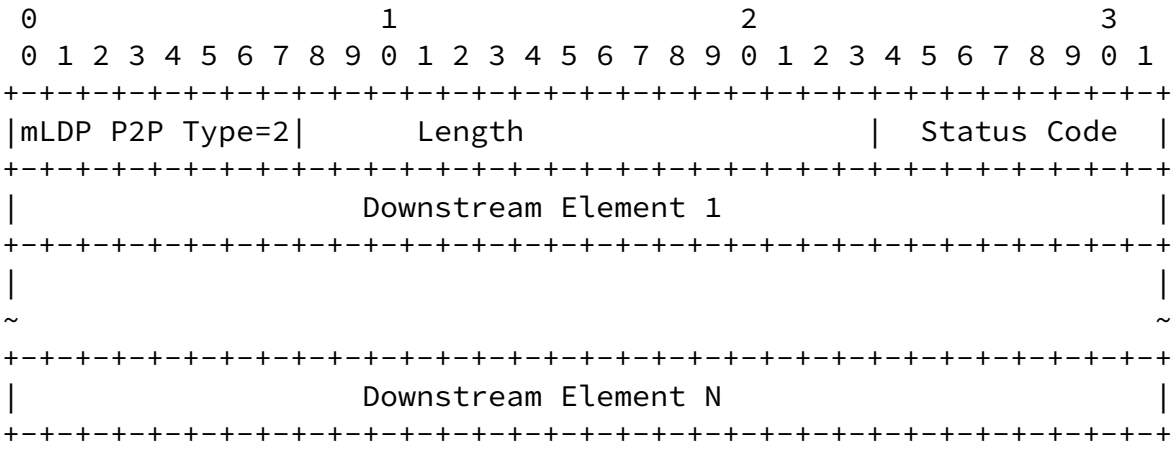
- P2P tunnel R1--R3--R5--R4, using inner label L4.

- P2P tunnel R1--R3--R5, using inner label L5.

So that R4/R5 will receive same packets as from the interface between R2 and R4/R5, just from different interface.

4.2. Protocol Extensions for P2P Based Local Protection

A new type of LDP MP Status Value Element is introduced, for notifying downstream LSRs and respective labels. It is encoded as follows:

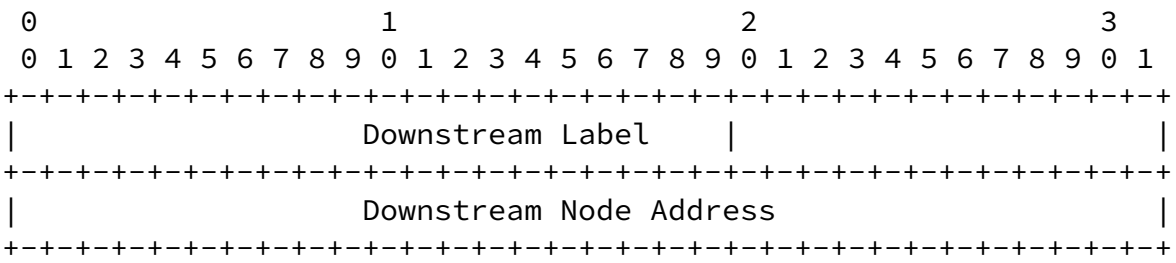


Status Code: 1 = Advertise the existing downstream LSRs
2 = Withdraw the deleted downstream LSRs

Encapsulation Status Code of mLDP Local Protection using P2P LSP

Figure 2

The Downstream Element is encoded as follows:

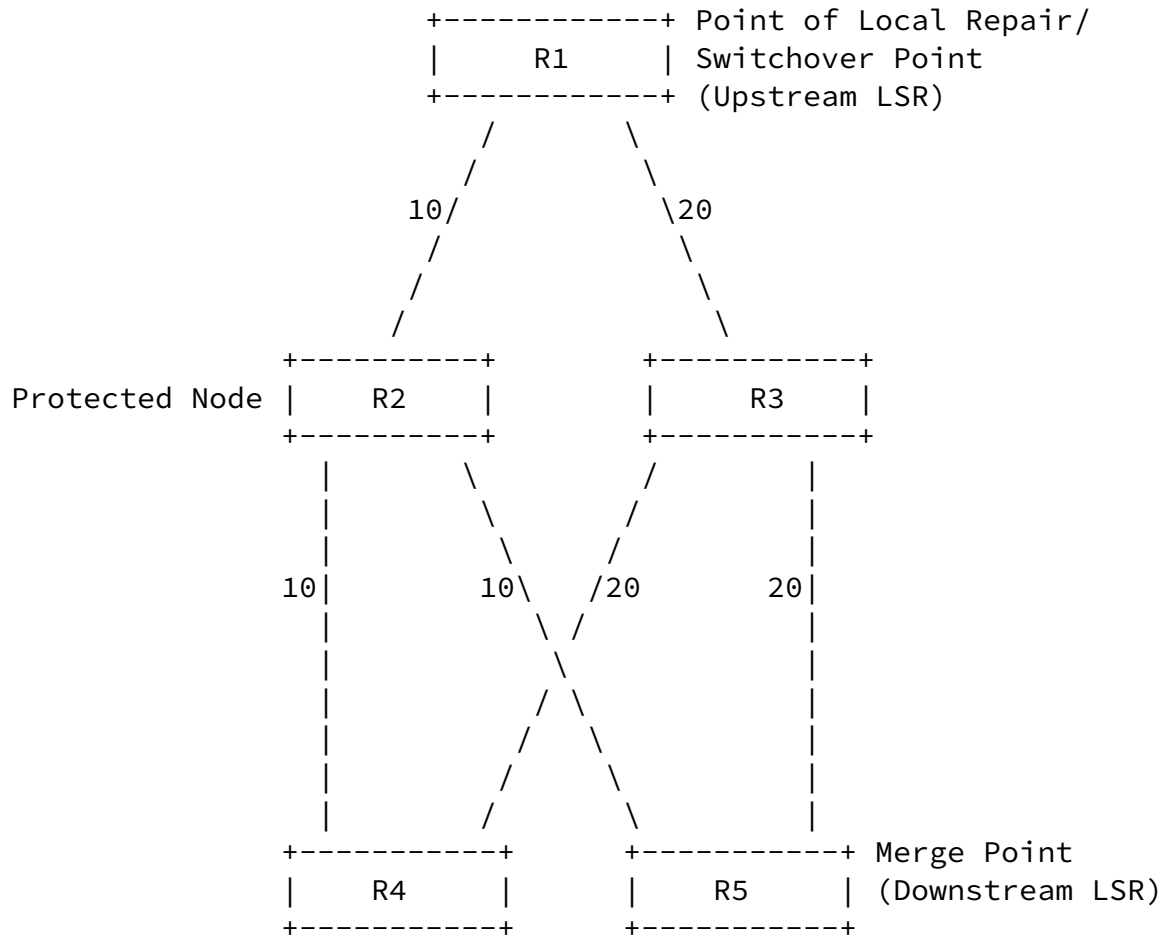


Downstream Element in mLDP P2P Encapsulation Status Code

Figure 3

5. mLDP Local Protection using P2MP LSP

Making use of IGP-FRR results, LDP can build the backup mLDP LSP among PLR, the protected node, and MPs (the downstream nodes of the protected node). In the cases where the amount of downstream nodes are huge, this mechanism can avoid unnecessary packet duplication on PLR, so that protect the network from traffic congestion risk.



mLDP Local Protection using P2MP LSP Example

Figure 4

In Figure 4 (P2MP Based mLDP Local Protection Example), the preferential path from R1 to R4/R5 is through R2, and the secondary path is through R3. In this case, the mLDP LSP will be established according to the IGP preferential path as R1--R2--R4/R5. This section will take the Protected Node as R2 for example, actually the Protected Node can be any Transit node of the mLDP LSP.

As the Protected Node, R2 will announce its selected upstream node R1 to all its downstream nodes, which are R4 and R5 in this example. So that R4 and R5 can consider R1 as the root node of the backup mLDP LSP, and trigger the backup LSP signaling. At the mean time, R4/R5 will bind the backup ILM entry to the primary NHLFE(s), so that the traffic receiving from backup mLDP LSP can be merged locally to the primary LSP.

The primary LSP and backup LSP are differentiated by the signaling

procedure, so normally PLR can only feed traffic only on the primary path. When the link between R1 and R2 fails, or R2 node fails, R1 will switch the traffic to the preset backup path quickly.

In this scenario, if R2 is protected by two P2P LSPs as R1--R3--R4 and R1--R3--R5, the traffic will be duplicated on R1, and R3 will receive two streams. If R2 is protected by mLDP LSP instead, R3 will only receive one stream, and the packet duplication will be done on R3.

5.1. Signaling Procedures for P2MP Based Local Protection

When the Protected Node (R2) determines its upstream LSR (R1), it will notify to all its downstream nodes immediately. If there are other LSR(s) becoming its downstream node(s) later, it will do the announcement for the new downstream node(s).

When the Merge Point (R4/R5) receive the notification, they individually determine the primary and secondary paths according to the IGP-FRR results. Then they will send out label mapping messages including an LDP MP Status TLV that carries a FRR Status Code to indicate the primary path and secondary path. The backup path is uniquely identified by root address, opaque value, PLR Node address, and Protected Node address.

When the transit nodes of the secondary LSP receive the FRR label mapping message, they can easily consider it as a new mLDP LSP establishment, and follow the existing protocol procedures. The only modification for these nodes is dealing with the FRR FEC, which is identified by root address, opaque value, PLR address, and Protected Node address.

When the Point of Local Repair (R1) receive the FRR label mapping message, it will generate the backup forwarding entry for the specific LSP, which is identified by the root address and opaque value in the message, and bind and backup forwarding state to the specific primary entry, which is indicated by the Protected Node address in the message. Note that there might be more than one backup forwarding entries for a specific protected node.

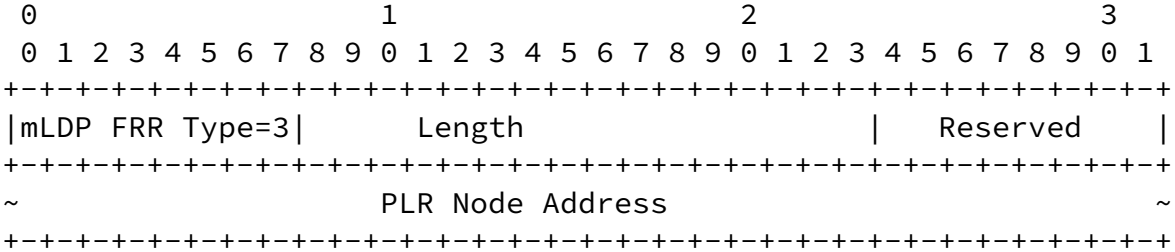
To avoid the backup LSP going through the Protected Node, additional path selection rule(s) can be applied, such as not-via policy. This part is under study, and will be added in the future.

When failure is detected by PLR, it will switch the traffic to the secondary path. At the mean time, MP will locally merge the traffic back to the primary LSP.

When Merge Point(s) see the next hop to Root changed, it/they will advertise the new mapping, and the traffic will re-converge to the new primary path.

5.2. Protocol extensions for P2MP Based Local Protection

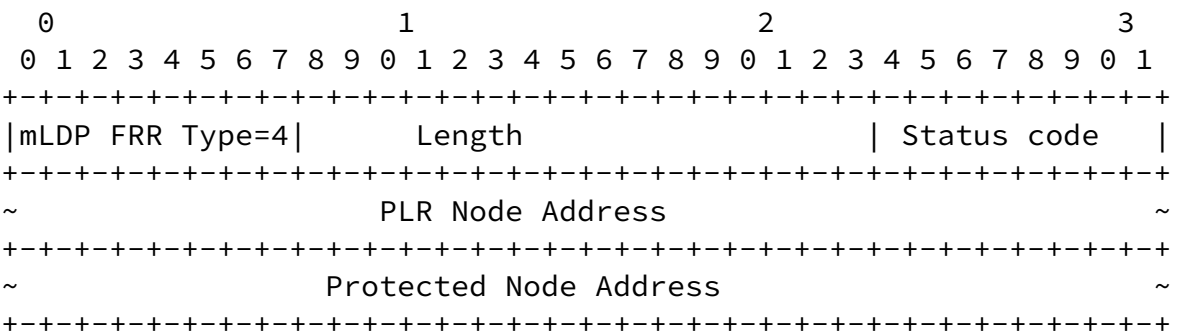
A new type of LDP MP Status Value Element is introduced, for notifying upstream LSR. It is encoded as follows:



P2MP Based mLDP Local Protection Status Code1

Figure 5

Besides, another new type of LDP MP Status Value Element is introduced, for setting up secondary mLDP LSP. It is encoded as follows:



P2MP Based mLDP Local Protection Status Code2

Figure 6

mLDP FRR Type: Type 4 (to be assigned by IANA)

Length: If the Address Family is IPv4, the Address Length MUST be 4; if the Address Family is IPv6, the Address Length MUST be 16.

Status code: 1 = Primary path for traffic forwarding
2 = Secondary path for traffic forwarding

PLR Node Address: The host address of the PLR Node.

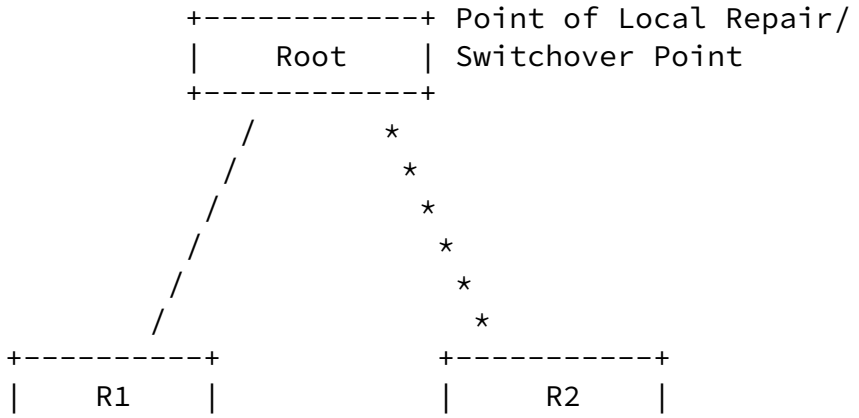
Protected Node Address: The host address of the Protected Node.

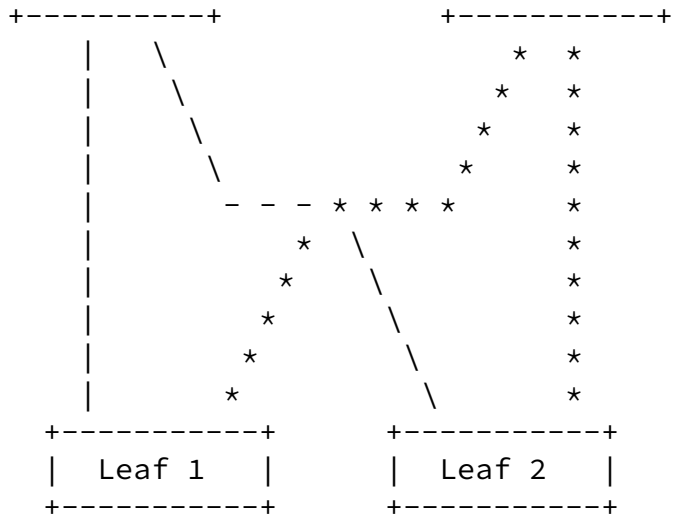
P2MP Based mLDP Local Protection Status Code Parameters

Figure 7

6. mLDP End-to-End Protection using LDP/mLDP Multiple Topology

[I-D.ietf-mpls-ldp-multi-topology] also provides the mechanism to setup disjointed LSPs within different topologies. So that applications can use these redundant LSPs for end-to-end protection.

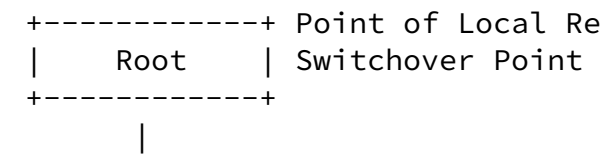


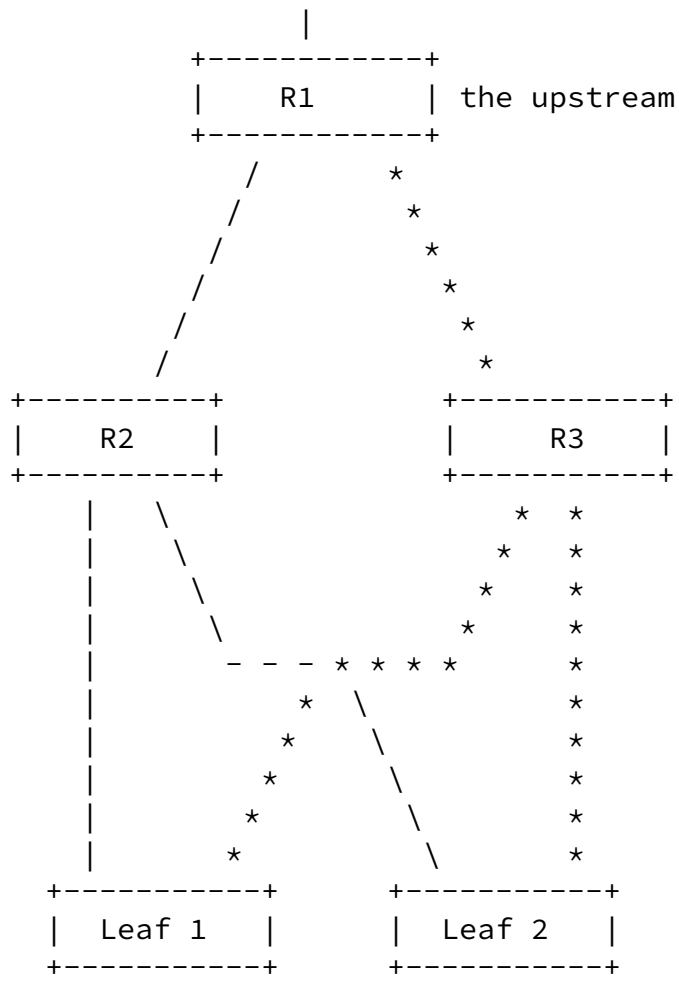


mLDP End-to-end Protection Example

Figure 8

In Figure 8 (mLDP End-to-end Protection Example), there are two separated topologies from Root node to Leaf 1 and Leaf 2. For the same root address and opaque value, the Leaf node can trigger mLDP LSPs in each topology. Root node can setup 1:1 or 1+1 end-to-end protection, using these two mLDP LSPs.





mLDP End-to-end Protection with Shared Upstream Node

Figure 9

In Figure 9 (mLDP End-to-end Protection with Shared Upstream Node Example), there are two separated topologies from Root node to Leaf 1 and Leaf 2 except the link between R1 and Root node. For the same root address and opaque value, the Leaf node can trigger mLDP LSPs in each topology. Root node can setup 1:1 or 1+1 end-to-end protection, using these two mLDP LSPs. The differece in this example comparing to the last example where the priamry and backup topology are totatlly disjoint, if there is a link failure between the Root and R1 or node R1 fails, there is no protection available.

6.1. Signaling Procedures for MT Based End-to-end Protection

Using the signaling procedure provied by [I-D.ietf-mpls-ldp-multi-topology], Leaf 1 and Leaf 2 are able to trigger mLDP LSPs in different topologies, sending label mapping messages with same root address, same opaque value, different MT-ID and different label. When the Root node receives the label mapping messages from different topologies, it will set up two mLDP LSPs for application as end-to-end protection. Failure detection for the primary mLDP LSP is outside the scope of this document. Either Root node or Leaf node can be the Failure Detector.

6.2. Protocol extensions for MT Based End-to-end Protection

The protocol extensions required to build mLDP LSPs in different topologies are defined in [I-D.ietf-mpls-ldp-multi-topology].

7. IANA Considerations

This memo includes the following requests to IANA:

- mLDP P2P Encapsulation type for LDP MP Status Value Element.
- mLDP FRR types for LDP MP Status Value Element.

8. Manageability Considerations

[Editors Note - This section requires further discussion]

8.1. Control of Function and Policy

8.2. Information and Data Models

8.3. Liveness Detection and Monitoring

8.4. Verifying Correct Operation

8.5. Requirements on Other Protocols and Functional Component

8.6. Impact on Network Operation

8.7. Policy Control

9. Security Considerations

The same security considerations apply as for the base LDP specification, as described in [RFC5036]. The protocol extensions specified in this document do not provide any authorization mechanism for controlling the set of LSRs that may attempt to join a mLDP protection session. If such authorization is desirable, additional mechanisms, outside the scope of this document, are needed.

Note that authorization policies should be implemented and/or configure at all the nodes involved .

10. Acknowledgements

We would like to thank authors of draft-ietf-mpls-mp-ldp-reqs and the authors of draft-ietf-mpls-ldp-multi-topology from which some text of this document has been inspired. We also would like to thank Robin Li, Tao Zhou and Lujun Wan for their comments and suggestions to the draft.

11. References

11.1. Normative References

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Authors' Addresses

Quintin Zhao
Huawei Technology
125 Nagog Technology Park
Acton, MA 01719
US

Email: quintin.zhao@huawei.com

Emily Chen
Huawei Technology
2330 Central Expressway
Santa Clara, CA 95050
US

Email: emily.chenying@huawei.com