

Internet Engineering Task Force
Internet-Draft
Intended status: Standards Track
Expires: April 18, 2014

Q. Zhao
Huawei Technology
L. Fang
C. Zhou
Cisco Systems
L. Li
China Mobile
K. Raza
Cisco Systems
October 14, 2013

LDP Extensions for Multi Topology Routing
draft-ietf-mpls-ldp-multi-topology-09.txt

Abstract

Multi-Topology (MT) routing is supported in IP networks with the use of MT aware IGP. In order to provide MT routing within Multiprotocol Label Switching (MPLS) Label Distribution Protocol (LDP) networks new extensions are required.

This document describes the LDP protocol extensions required to support MT routing in an MPLS environment.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <http://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on April 20, 2014.

Copyright Notice

Copyright (c) 2013 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal

Internet-Draft

LDP Multi Topology Extensions

October 2013

Provisions Relating to IETF Documents

(<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Internet-Draft

LDP Multi Topology Extensions

October 2013

Table of Contents

1.	Introduction	4
2.	Terminology	4
3.	Signaling Extensions	5
3.1.	Topology-Scoped Forwarding Equivalence Class (FEC)	5
3.2.	New Address Families: MT IP	5
3.3.	LDP FEC Elements with MT IP AF	6
3.4.	IGP MT-ID Mapping and Translation	7
3.5.	LDP MT Capability Advertisement	7
3.5.1.	Protocol Extension	7
3.5.2.	Procedures	9
3.6.	LDP Sessions	10
3.7.	Reserved MT ID Values	10
4.	MT Applicability on FEC-based features	10
4.1.	Typed Wildcard FEC Element	10
4.2.	End-of-LIB	11
4.3.	LSP Ping	11
4.3.1.	New FEC Sub-Types	11
4.3.2.	MT LDP IPv4 FEC Sub-TLV	12
4.3.3.	MT LDP IPv6 FEC Sub-TLV	12
4.3.4.	Operation Considerations	13
5.	Error Handling	13
5.1.	MT Error Notification for Invalid Topology ID	13
6.	Backwards Compatibility	13
7.	MPLS Forwarding in MT	14
8.	Security Consideration	14
9.	IANA Considerations	14
10.	Manageability Considerations	16
10.1.	Control of Function and Policy	16
10.2.	Information and Data Models	16
10.3.	Liveness Detection and Monitoring	16
10.4.	Verify Correct Operations	16
10.5.	Requirements On Other Protocols	16
10.6.	Impact On Network Operations	16
11.	Contributors	16

12. Acknowledgement	18
13. References	18
13.1. Normative References	18
13.2. Informative References	19
Authors' Addresses	19

[1.](#) Introduction

Multi-Topology (MT) routing is supported in IP networks with the use of MT aware IGPs. It would be advantageous for communications Service Providers (CSP) to support Multiple Topologies (MT) within MPLS environments (MPLS-MT). The benefits of MPLS-MT enabled networks include:

- o A CSP may want to assign varying Quality of Service (QoS) profiles to traffic, based on a specific MT.
- o Separate routing and MPLS domains may be used to isolated multicast and IPv6 islands within the backbone network.
- o Specific IP address space could be routed across an MT based on security or operational isolation requirements.
- o Low latency links could be assigned to an MT for delay sensitive traffic.
- o Management traffic could be separated from customer traffic using multiple MTs, where the management traffic MT does not use links that carries customer traffic.

This document describes the Label Distribution Protocol (LDP) procedures and protocol extensions required to support MT routing in an MPLS environment.

This document also updates [RFC4379](#) by defining two new FEC types for

Label Switched Path (LSP) ping.

2. Terminology

This document uses MPLS terminology defined in [[RFC5036](#)]. Additional terms are defined below:

- o MT-ID: A 16 bit value used to represent the Multi-Topology ID.
- o Default MT Topology: A topology that is built using the MT-ID default value of 0.
- o MT Topology: A topology that is built using the corresponding MT-ID.

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](#)].

Zhao, et al.

Expires April 20, 2014

[Page 4]

Internet-Draft

LDP Multi Topology Extensions

October 2013

3. Signaling Extensions

3.1. Topology-Scoped Forwarding Equivalence Class (FEC)

LDP assigns and binds a label to a Forwarding Equivalence Class (FEC), where a FEC is a list of one or more FEC elements. To setup LSPs for unicast IP routing paths, LDP assigns local labels for IP prefixes, and advertises these labels to its peers so that an LSP is setup along the routing path. To setup MT LSPs for IP prefixes under a given topology scope, the LDP "prefix-related" FEC element must be extended to include topology information. This implies that MT-ID becomes an attribute of Prefix-related FEC element, and all FEC-Label binding operations are performed under the context of given topology (MT-ID).

The following [Subsection 3.2](#) (New Address Families (AF): MT IP) defines the extension required to bind "prefix-related" FEC to a topology.

3.2. New Address Families: MT IP

The LDP base specification [[RFC5036](#)] ([Section 4.1](#)) defines the

"Prefix" FEC Element. The "Prefix" encoding is defined for a given "Address Family" (AF), and has length (in bits) specified by the "PreLen" field.

To extend IP address families for MT, two new Address Families named "MT IP" and "MT IPv6" are used to specify IPv4 and IPv6 prefixes within a topology scope.

The format of data associated with these new Address Families are described below:

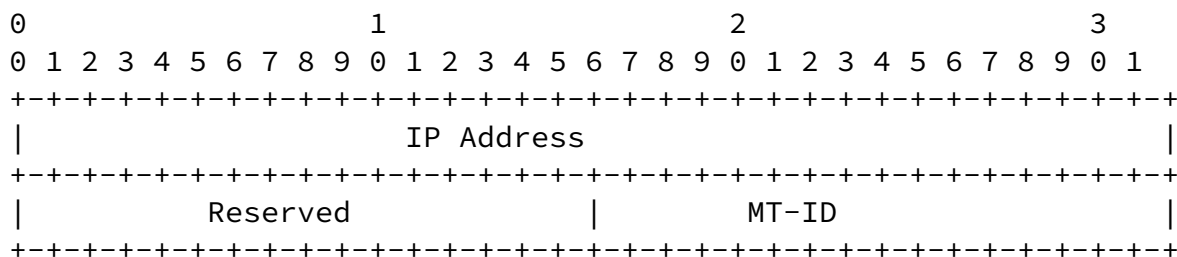


Figure 1: MT IP Address Family Format

Where "IP Address" is an IPv4 and IPv6 address/prefix for "MT IP" and "MT IPv6" AF respectively, and the field "MT-ID" corresponds to 16-bit Topology ID for given address.

Where 16-bit "MT-ID" field defines the Topology ID, and the definition and usage of the rest fields in the FEC Elements are same as defined for IP/IPv6 AF. The value of MT-ID 0 corresponds to default topology and MUST be ignored on receipt so as to not cause any conflict/confusion with existing non-MT procedures.

The defined FEC Elements with "MT IP" Address Family can be used in any LDP message and procedures that currently specify and allow the use of FEC Elements with IP/IPv6 Address Family.

3.3. LDP FEC Elements with MT IP AF

The following section specifies the format extensions of the existing LDP FEC Elements. The "Address Family" of these FEC elements will be set to "MT IP" or "MT IPv6".

The MT Prefix FEC element encoding is as follows:

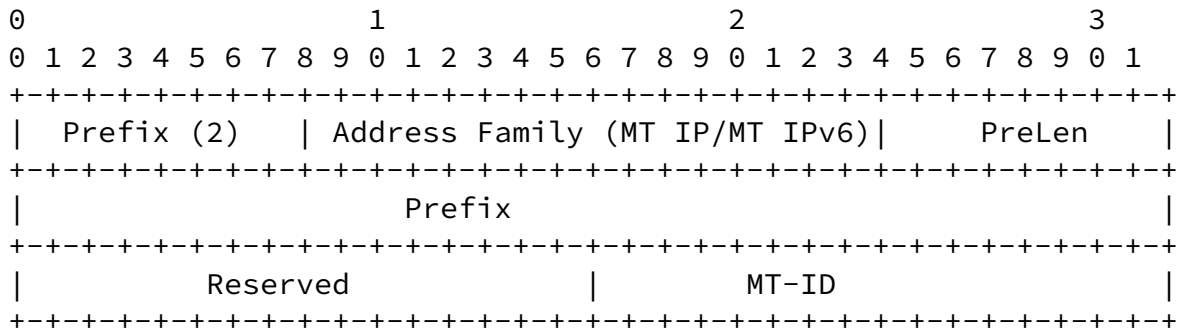
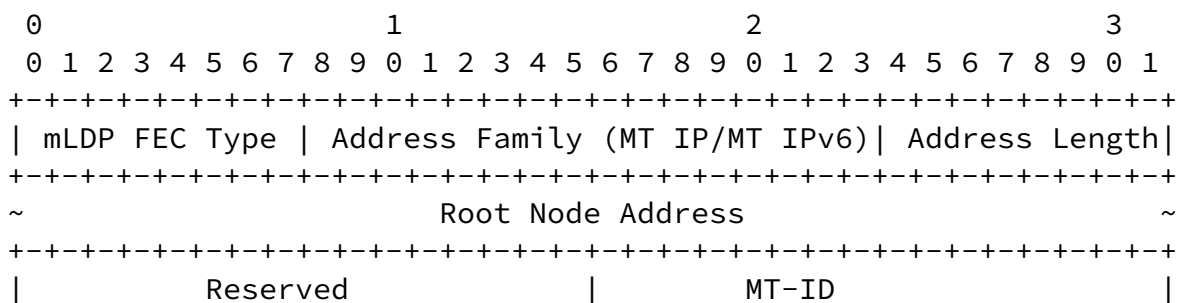


Figure 2: MT Prefix FEC Element Format

Similarly, the MT mLDP FEC elements encoding is as follows, where the mLDP FEC Type can be P2MP(6), MP2MP-up(7), and MP2MP-down(8):



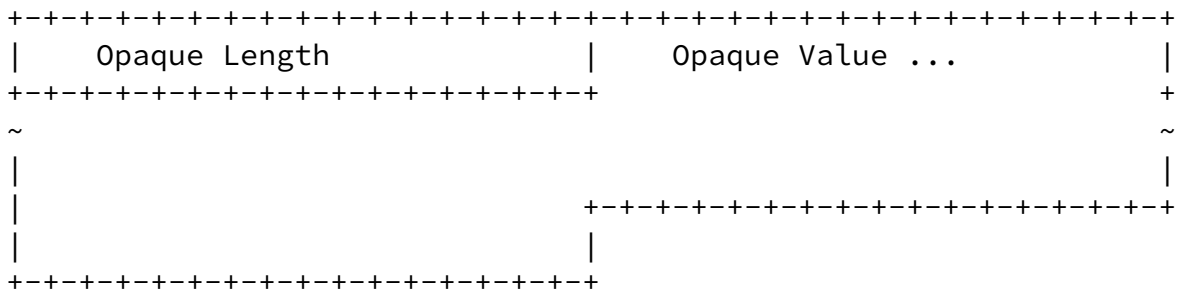


Figure 3: MT mLDP FEC Element Format

The MT Typed Wildcard FEC element encoding is as follows:

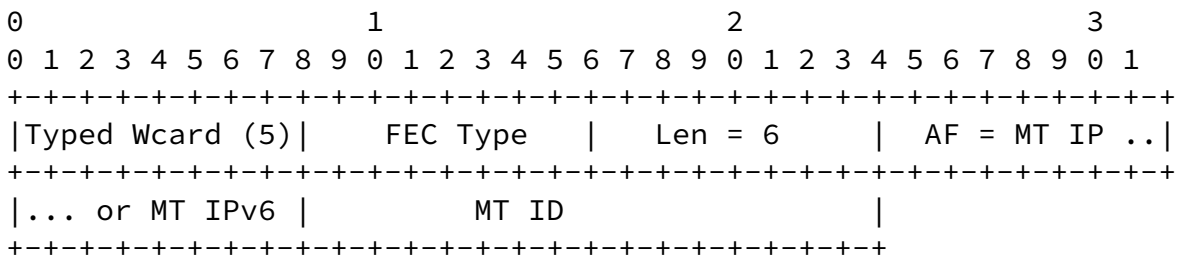


Figure 4: MT Typed Wildcard FEC Element

3.4. IGP MT-ID Mapping and Translation

The non-reserved non-special IGP MT-ID values can be used and carried in LDP without the need for translation. However, there is a need for translating reserved or special IGP MT-ID values to corresponding LDP MT-IDs. The corresponding special and reserved LDP MT-ID values are requested In [Section 9](#). (IANA Considerations).

3.5. LDP MT Capability Advertisement

3.5.1. Protocol Extension

We specify a new LDP capability, named "Multi-Topology (MT)", which is defined in accordance with LDP Capability definition guidelines [[RFC5561](#)]. The LDP "MT" capability can be advertised by an LDP speaker to its peers either during the LDP session initialization or

after the LDP session is setup to announce LSR capability to support

MT for the given IP address family. An LDP speaker MUST NOT send an MT AF unless the peer has said it can handle it.

The MT capability is specified using "Multi-Topology Capability" TLV. The "Multi-Topology Capability" TLV format is in accordance with LDP capability guidelines as defined in [RFC5561]. To be able to specify IP address family, the capability specific data (i.e. "Capability Data" field of Capability TLV) is populated using "Typed Wildcard FEC Element" as defined in [RFC5918].

The format of "Multi-Topology Capability" TLV is as follows:

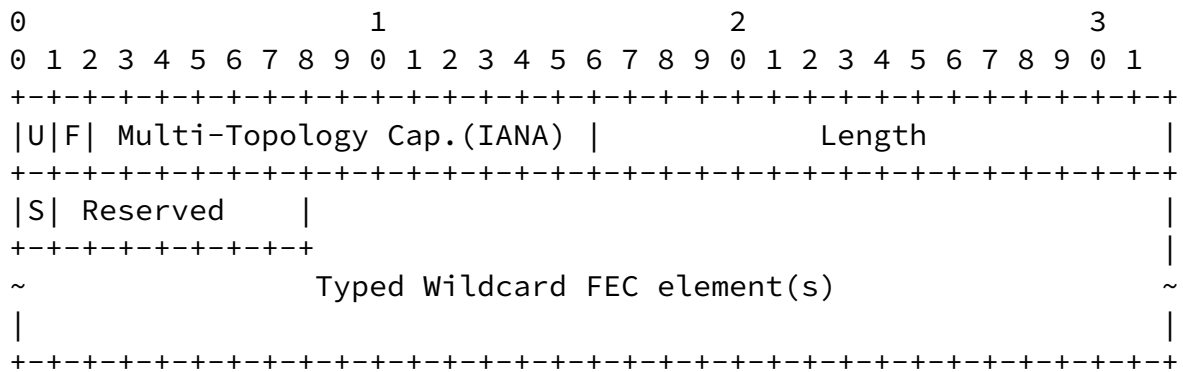


Figure 5: Multi-Topology Capability TLV Format

Where:

- o U- and F-bits: MUST be 1 and 0, respectively, as per [Section 3](#). (Signaling Extensions) of LDP Capabilities [RFC5561].
- o Multi-Topology Capability: Capability TLV type (IANA assigned)
- o S-bit: MUST be 1 if used in LDP "Initialization" message. MAY be set to 0 or 1 in dynamic "Capability" message to advertise or withdraw the capability respectively.
- o Typed Wildcard FEC element(s): One or more elements specified as the "Capability data".
- o Length: length of Value field, starting from S bit, in octets.
- o The encoding of Typed Wildcard FEC element, as defined in [RFC5918], is defined in the [section 3.3](#) (Typed Wildcard FEC Element) of this document.

In the case that the LDP initialization message can not hold all the MTs to be advertised, dynamic "Capability" message to advertise the

capability" must be supported.

3.5.2. Procedures

To announce its MT capability for an IP address family, LDP FEC type, and Multi Topology, an LDP speaker sends an "MT Capability" including the exact Typed Wildcard FEC element with corresponding "AddressFamily" field (i.e., set to "MT IP" for IPv4 and set to "MT IPv6" for IPv6 address family), corresponding "FEC Type" field (i.e., set to "P2P", "P2MP", "MP2MP"), and corresponding "MT-ID". To announce its MT capability for both IPv4 and IPv6 address family, or for multiple FEC types, or for multiple Multi Topologies, an LDP speaker sends "MT Capability" with one or more MT Typed FEC elements in it.

- o The capability for supporting multi-topology in LDP can be advertised during LDP session initialization stage by including the LDP MT capability TLV in LDP Initialization message. After an LDP session is established, the MT capability can also be advertised or withdrawn using Capability message (only if "Dynamic Announcement" capability [[RFC5561](#)] has already been successfully negotiated).
- o If an LSR has not advertised MT capability, its peer MUST NOT send label mapping messages that include MT identifier to this LSR.
- o If an LSR receives a Label Mapping message with an MT parameter from downstream LSR-D and its upstream LSR-U has not advertised MT capability, an LSP for the MT will not be established.
- o If an LSR is changed from non-MT capable to MT capable, it sets the S bit in MT capability TLV and advertises via the Capability message. The existing LSP is treated as LSP for default MT (ID 0).
- o If an LSR is changed from LDP-MT capable to non-MT capable, it initiates withdraw of all label mapping for existing LSPs of all non-default MTs. It also cleanup all the LSPs of all non-default MTs locally. Then it clears the S bit in MT capability TLV and advertises via the Capability message. When an LSR knows the peer node is changed from LDP-MT capable to non-MT capable, it cleanup all the LSPs of all non-default MTs locally and initiate withdraw of all label mapping for existing LSPs of all non-default MTs. Both sides of the nodes send label release to its peer once they receive the label release messages even both sides have already cleaned up all the LSPs locally.

- o If an LSR is changed from IGP-MT capable to non-MT capable, it may wait until the routes update to withdraw FEC and release the label mapping for existing LSPs of specific MT.

[3.6.](#) LDP Sessions

Since using different label spaces for different topologies would imply significant changes to the data plane, a single global label space is supported in this solution. There will be one session supported for each pair of peer, even there are multiple topologies supported between these two peers.

[3.7.](#) Reserved MT ID Values

Certain MT topologies are assigned to serve predetermined purposes.

In [Section 9](#). (IANA Considerations), this document defines a new IANA registry "LDP Multi-Topology ID Name Space" under IANA "LDP Parameter" namespace to keep an LDP MT-ID reserved value.

If an LSR receives a FEC element with an "MT-ID" value that is "Reserved" for future use (and not IANA allocated yet), the LSR must abort the processing of the FEC element, and SHOULD send a notification message with status code "Invalid MT-ID" to the sender.

[4.](#) MT Applicability on FEC-based features

[4.1.](#) Typed Wildcard FEC Element

[RFC5918] extends base LDP and defines Typed Wildcard FEC Element framework. Typed Wildcard FEC element can be used in any LDP message to specify a wildcard operation/action for given type of FEC.

The MT extensions defined in document do not require any extension to procedures for Typed Wildcard FEC element, and these procedures apply as-is to MT wildcarding. The MT extensions, though, allow use of "MT IP" or "MT IPv6" in the Address Family field of the Typed Wildcard FEC element in order to use wildcard operations in the context of a

given topology. The use of MT-scoped address family also allows us to specify MT-ID in these operations.

The defined format in [Section 3.3](#) (Typed Wildcard FEC Element) allows an LSR to perform wildcard FEC operations under the scope of a topology. If an LSR wishes to perform wildcard operation that applies to all topologies, it can use a "Wildcard Topology" MT-ID. For example, upon local configuration of topology "x", an LSR may send a wildcard label withdraw request with MT-ID "x" to withdraw all

its labels from the peer that advertised under the scope of topology "x". Additionally, upon a global configuration change, an LSR may send a wildcard label withdraw with the MT-ID set to "Wildcard Topology" to withdraw all its labels under all topologies from the peer.

[4.2.](#) End-of-LIB

[RFC5919] specifies extensions and procedures for an LDP speaker to signal its convergence for a given FEC type towards a peer. The procedures defined in [\[RFC5919\]](#) applies as-is to an MT FEC element. This allows an LDP speaker to signal its IP convergence using Typed Wildcard FEC element, and its MT IP convergence per topology using a MT Typed Wildcard FEC element.

[4.3.](#) LSP Ping

[RFC4379] defines procedures to detect data-plane failures in MPLS LSPs via LSP ping. That specification defines a "Target FEC Stack" TLV that describes the FEC stack being tested. This TLV is sent in an MPLS echo request message towards LSPs egress LSR, and is forwarded along the same data path as other packets belonging to the FEC.

"Target FEC Stack" TLV contains one or more sub-TLVs pertaining to different FEC types. [Section 3.2 of \[RFC4379\]](#) defines Sub-Types and format for the FEC. To support LSP ping for MT LDP LSPs, this document defines following extensions to [\[RFC4379\]](#).

[4.3.1.](#) New FEC Sub-Types

We define two new FEC types for LSP ping:

- o MT LDP IPv4 FEC
- o MT LDP IPv6 FEC

We also define following new sub-types for sub-TLVs to specify these FECs in the "Target FEC Stack" TLV of [[RFC4379](#)]:

Sub-Type -----	Length -----	Value Field -----
TBA5	8	MT LDP IPv4 prefix
TBA6	20	MT LDP IPv6 prefix

Figure 6: new sub-types for sub-TLVs

The rules and procedures of using these sub-TLVs in an MPLS echo request message are same as defined for LDP IPv4/IPv6 FEC sub-TLV types in [[RFC4379](#)].

[4.3.2](#). MT LDP IPv4 FEC Sub-TLV

The format of "MT LDP IPv4 FEC" sub-TLV to be used in a "Target FEC Stack" [[RFC4379](#)] is:

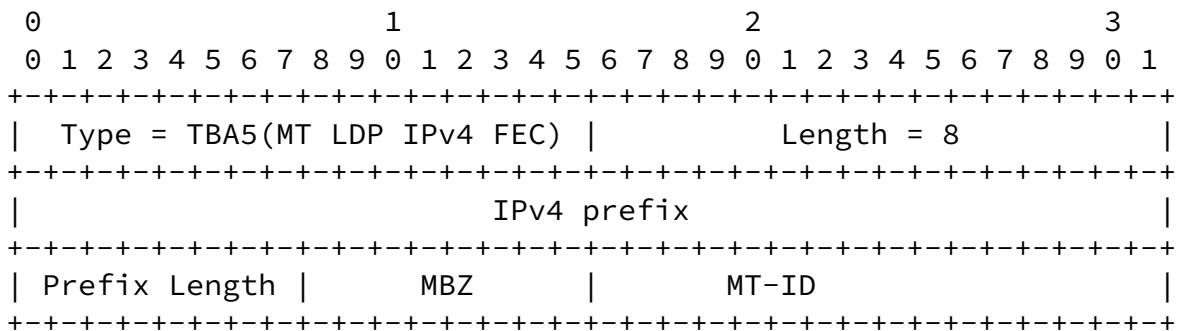


Figure 7: MT LDP IPv4 FEC sub-TLV

The format of this sub-TLV is similar to LDP IPv4 FEC sub-TLV as defined in [[RFC4379](#)]. In addition to "IPv4 prefix" and "Prefix Length" fields, this new sub-TLV also specifies MT-ID (Multi-Topology ID). The Length for this sub-TLV is 5.

4.3.3. MT LDP IPv6 FEC Sub-TLV

The format of "MT LDP IPv6 FEC" sub-TLV to be used in a "Target FEC Stack" [RFC4379] is:

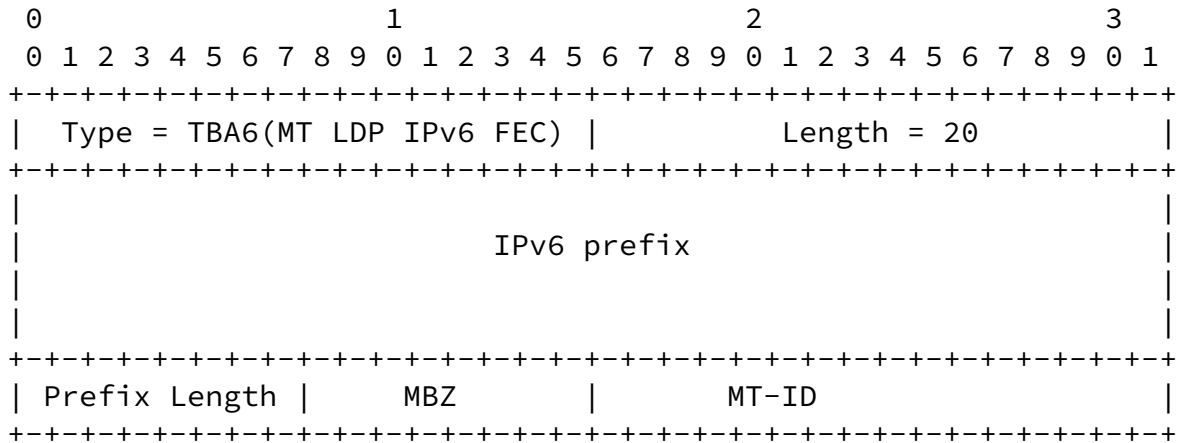


Figure 8: MT LDP IPv6 FEC sub-TLV

The format of this sub-TLV is similar to LDP IPv6 FEC sub-TLV as

defined in [RFC4379]. In addition to "IPv6 prefix" and "Prefix Length" fields, this new sub-TLV also specifies MT-ID (Multi-Topology ID). The Length for this sub-TLV is 17.

4.3.4. Operation Considerations

To detect data plane failures using LSP Ping for a specific topology, the router will initiate an LSP Ping request with the target FEC stack TLV containing LDP MT IP Prefix Sub-TLV in the Echo Request packet. The Echo Request packet is sent with the label bound to the IP Prefix in the topology. Once the echo request packet reaches the target router, it will process the packet and perform checks for the LDP MT IP Prefix sub-TLV present in the Target FEC Stack as described in [RFC4379] and respond according to [RFC4379] processing rules. For the case that the LSP ping with return path not specified, the reply packet must go through the default topology instead of the topology where the Echo Request goes through.

5. Error Handling

The extensions defined in this document utilize the existing LDP error handling defined in [[RFC5036](#)]. If an LSR receives an error notification from a peer for a session, it terminates the LDP session by closing the TCP transport connection for the session and discarding all MT-ID label mappings learned via the session.

5.1. MT Error Notification for Invalid Topology ID

If an LSR has advertised an MT Capability TLV using the Initialization message or Capability message, which includes Typed Wildcard FEC elements with specific MT-IDs, and it receives an MT message with a MT-ID which is not included in the supported list, it should response this "Invalid Topology ID" status code.

6. Backwards Compatibility

The MPLS-MT solution is backwards compatible with existing LDP enhancements defined in [[RFC5036](#)], including message authenticity, integrity of message, and topology loop detection.

The legacy node which does not support MT should not receive any MT related LDP messages. In case the bad things does happen, according to [[RFC5036](#)], processing of such message should be aborted.

7. MPLS Forwarding in MT

Although forwarding is out of the scope of this draft, we include some forwarding consideration for informational purpose here.

The specified signaling mechanisms allow all the topologies to share the platform-specific label space; this is the feature that allows the existing data plane techniques to be used; and there is no way for the data plane to associate a received packet with any one topology, meaning that topology-specific label spaces cannot be used.

8. Security Consideration

No specific security issues with the defined solutions are known. The defined extensions in this document do not introduce any new security considerations beyond that already apply to the base LDP specification [RFC5036] and [RFC5920].

9. IANA Considerations

The document introduces following new protocol elements that require IANA consideration and assignments:

- o New LDP Capability TLV: "Multi-Topology Capability" TLV (requested code point: TBA1 from LDP registry "TLV Type Name Space").
- o New Status Code: "Multi-Topology Capability not supported" (requested code point: TBA2 from LDP registry "Status Code Name Space"). This status code is only used by node that supports MT when decided to withdraw this capability.
- o New Status Code: "Invalid Topology ID" (requested code point: TBA3 from LDP registry "Status Code Name Space").

Registry: Range/Value -----	Description -----
TBA1	Multi-Topology Capability
TBA2	Multi-Topology Capability not supported
TBA3	Invalid Topology ID

Figure 9: New Code Points for LDP Multi Topology Extensions

- o New address families under IANA registry "Address Family Numbers":

- MT IP: Multi-Topology IP version 4 (requested codepoint: 26)
- MT IPv6: Multi-Topology IP version 6 (requested codepoint: 27)

Figure 10: Address Family Numbers

- o New registry "LDP Multi-Topology (MT) ID Name Space" under "LDP Parameter" namespace. The allocation policies for this registry are:

Range/Value	Purpose	Reference
0	Default/standard topology	
1	IPv4 in-band management	
2	IPv6 routing topology	
3	IPv4 multicast topology	
4	IPv6 multicast topology	
5	IPv6 in-band management	
6-3995	Reserved for future IGP topologies	
3996-4095	Reserved for IGP experimental topologies	
4096-4127	Reserved for LDP topologies	
4128-65534	Reserved for LDP experimental topologies	
65535	Wildcard Topology	

Figure 11: LDP Multi-Topology (MT) ID Name Space

- o New Sub-TLV Types for LSP ping: Following new sub-type values under TLV type 1 (Target FEC Stack) from "Multi-Protocol Label Switching (MPLS) Label Switched Paths (LSPs) Ping Parameters" registry, and "TLVs and sub-TLVs" sub-registry.

Sub-Type	Value Field
TBA4	MT LDP IPv4 prefix
TBA5	MT LDP IPv6 prefix

Figure 12: New Sub-TLV Types for LSP ping

IANA should allocate the next available numbers for these TBAs.

[10.](#) Manageability Considerations

[10.1.](#) Control of Function and Policy

There are capabilities that should be configurable to enable good manageability. One such example is to allow enable or disable LDP Multi-Topology capability. It is assumed that the mapping of the LDP MT ID and IGP MT ID is manually configured on every router by default. If an automatic mapping between IGP MT IDs and LDP MT IDs is needed, there must be explicit configuration to do so.

[10.2.](#) Information and Data Models

[draft-li-mpls-ldp-mt-mib.txt](#) describes the PCEP MIB, there is no new MIB Objects for this document.

[10.3.](#) Liveness Detection and Monitoring

Mechanisms defined in this document do not imply any new liveness detection and monitoring requirements.

[10.4.](#) Verify Correct Operations

If an operator is trying to debug LDP MT enabled network and wants to make the association between the LDP label advertisement and the IGP routing advertisement, then the user must understand the mapping mechanism to convert the IGP MT ID to the LDP MT ID. This type of mapping mechanisms is out of the scope of this document.

[10.5.](#) Requirements On Other Protocols

If the LDP MT ID has an implicit dependency on IGP MT ID, then the corresponding IGP MT feature/s need to be supported.

[10.6.](#) Impact On Network Operations

Mechanisms defined in this document do not have any impact on network operations.

[11.](#) Contributors

Ning So

Internet-Draft

LDP Multi Topology Extensions

October 2013

2613 Fairbourne Cir.
Plano, TX 75082
USA

Email: ning.so@tatacommunications.com

Raveendra Torvi
Juniper Networks
10, Technoogy Park Drive
Westford, MA 01886-3140
US

Email: rtorvi@juniper.net

Huaimo Chen
Huawei Technology
125 Nagog Technology Park
Acton, MA 01719
US

Email: huaimochen@huawei.com

Emily Chen
2717 Seville Blvd, Apt 1205,
Clearwater, FL 33764
US

Email: emily.chen220@gmail.com

Chen Li
China Mobile
53A, Xibianmennei Ave.
Xunwu District, Beijing 01719
China

Email: lichenyj@chinamobile.com

Lu Huang
China Mobile
53A, Xibianmennei Ave.

Xunwu District, Beijing 01719
China

Email: huanglu@chinamobile.com

Daniel King
Old Dog Consulting

Zhao, et al.

Expires April 20, 2014

[Page 17]

Internet-Draft

LDP Multi Topology Extensions

October 2013

Email: E-mail: daniel@olddog.co.uk

Zhenbin Li
Huawei Technology
2330 Central Expressway
Santa Clara, CA 95050
US

Email: zhenbin.li@huawei.com

[12.](#) Acknowledgement

The authors would like to thank Dan Tappan, Nabil Bitar, Huang Xin, Eric Rosen, IJbrand Wijnands, Dimitri Papadimitriou, Yiqun Chai, pranjal Dutta, George Swallow, Curtis Villamizar, Adrian Farrel, Alia Atlas and Loa Anderson for their valuable comments on this draft.

[13.](#) References

[13.1.](#) Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC4379] Kompella, K. and G. Swallow, "Detecting Multi-Protocol Label Switched (MPLS) Data Plane Failures", [RFC 4379](#), February 2006.

- [RFC5036] Andersson, L., Minei, I., and B. Thomas, "LDP Specification", [RFC 5036](#), October 2007.
- [RFC5561] Thomas, B., Raza, K., Aggarwal, S., Aggarwal, R., and JL. Le Roux, "LDP Capabilities", [RFC 5561](#), July 2009.
- [RFC5918] Asati, R., Minei, I., and B. Thomas, "Label Distribution Protocol (LDP) 'Typed Wildcard' Forward Equivalence Class (FEC)", [RFC 5918](#), August 2010.
- [RFC5919] Asati, R., Mohapatra, P., Chen, E., and B. Thomas, "Signaling LDP Label Advertisement Completion", [RFC 5919](#), August 2010.

Zhao, et al.

Expires April 20, 2014

[Page 18]

Internet-Draft

LDP Multi Topology Extensions

October 2013

[13.2.](#) Informative References

- [RFC5920] Fang, L., "Security Framework for MPLS and GMPLS Networks", [RFC 5920](#), July 2010.

Authors' Addresses

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

Email: quintin.zhao@huawei.com

Luyuan Fang
Cisco Systems
300 Beaver Brook Road
Boxborough, MA 01719
US

Email: lufang@cisco.com

Chao Zhou
Cisco Systems
300 Beaver Brook Road
Boxborough, MA 01719
US

Email: czhou@cisco.com

Lianyuan Li
China Mobile
53A, Xibianmennei Ave.
Xunwu District, Beijing 01719
China

Email: lilianyuan@chinamobile.com

Zhao, et al.

Expires April 20, 2014

[Page 19]

Internet-Draft

LDP Multi Topology Extensions

October 2013

Kamran Raza
Cisco Systems
2000 Innovation Drive
Kanata, ON K2K-3E8, MA
Canada

Email: E-mail: skraza@cisco.com

