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Q. Zhao  
Huawei Technology  
L. Fang  
C. Zhou  
Cisco Systems  
L. Li  
China Mobile  
K. Raza  
Cisco Systems  
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LDP Extensions for Multi Topology Routing  
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## Abstract

Multi-Topology (MT) routing is supported in IP networks with the use of MT aware IGP protocols. In order to provide MT routing within Multiprotocol Label Switching (MPLS) Label Distribution Protocol (LDP) networks new extensions are required. This document updates [RFC4379](#).

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

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## [1.](#) 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](#)].

## [2.](#) Introduction

Multi-Topology (MT) routing is supported in IP networks with the use of MT aware IGP protocols. 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 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 LSP ping.

### [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 infers 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 as follows:

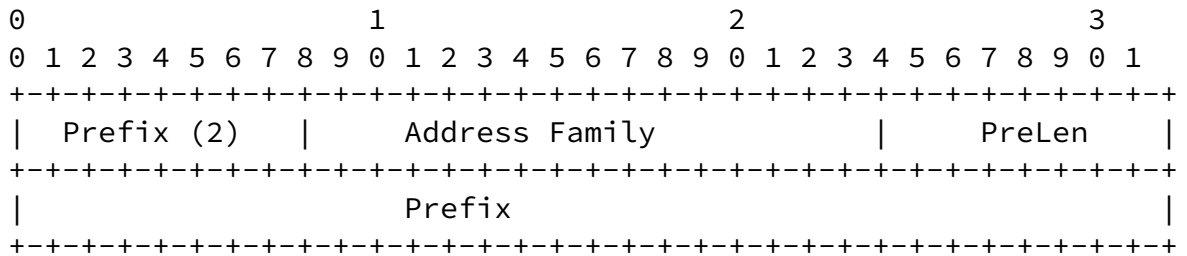


Figure 1: Prefix FEC Element Format [[RFC5036](#)]

Where "Prefix" encoding is as defined for given "Address Family" (AF), and whose length (in bits) is 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:

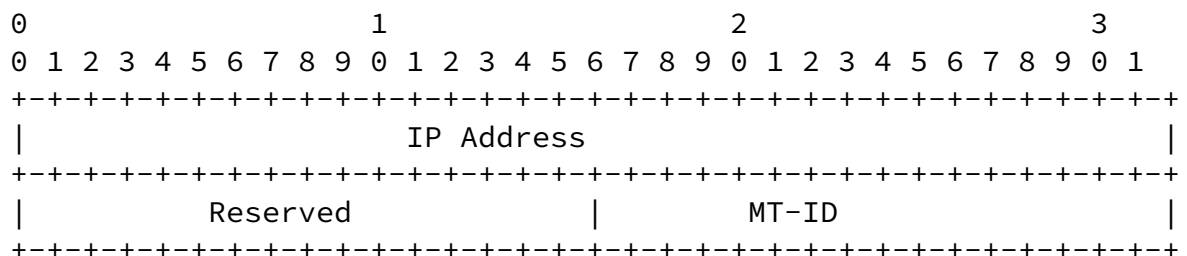


Figure 2: MT IP Address Family Format

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 proposed 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.

[RFC5036] does not specify the handling of "Unknown" Address Families. Therefore, [RFC5036] will need to be updated to include the handling procedure for unknown address families.

### 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:

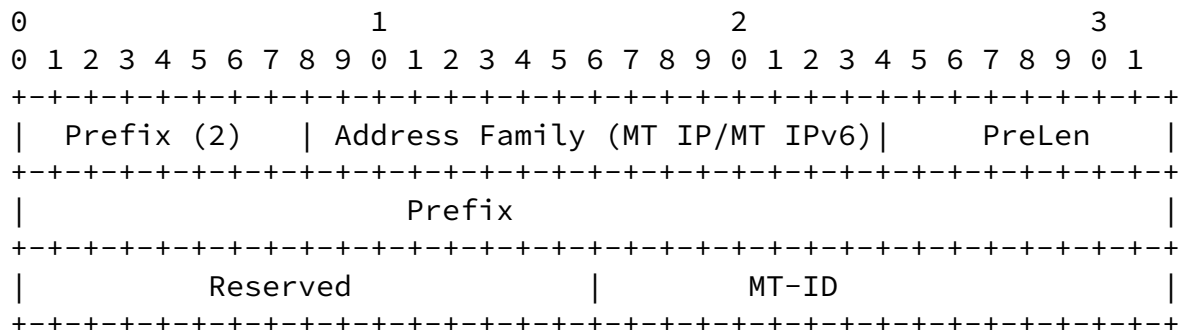


Figure 3: MT Prefix FEC Element Format

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):







### 3.5. LDP MT Capability Advertisement

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.

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:

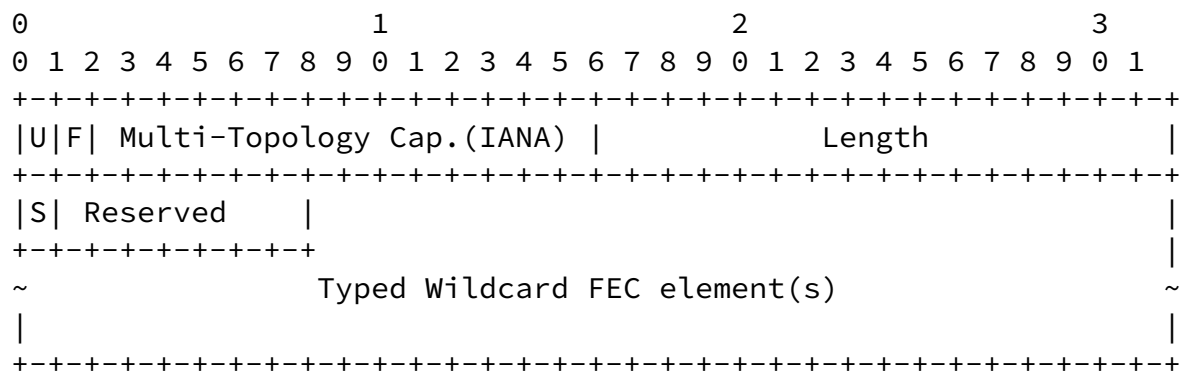


Figure 6: Multi-Topology Capability TLV Format

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: The length (in octets) of TLV.

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- 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.

### [3.6](#). Procedures

To announce its MT capability for an IP address family, LDP FEC type, and Multi Topology, an LDP speaker MAY send 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 MAY send "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 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 This document proposes to add a new notification event to signal the upstream that the downstream is not capable.
- 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 may initiate withdraw of all label mapping for existing LSPs of all non-default MTs. Then it clears the S bit in MT capability TLV

and advertises via the Capability message.

- 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.

### [3.7.](#) 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.

### [3.8.](#) Reserved MT ID Values

Certain MT topologies are assigned to serve predetermined purposes:

**Default-MT:** Default topology. This corresponds to OSPF default IPv4 and IPv6, as well as ISIS default IPv4. A value of 0 is proposed.

**ISIS IPv6 MT:** ISIS default MT-ID for IPv6.

**Wildcard-MT:** This corresponds to All-Topologies. A value of 65535 (0xffff) is proposed.

In [Section 9](#). (IANA Considerations) this document proposes 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 proposed 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.

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The proposed 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 advertized 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 MAY allow 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. The 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 proposes 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 [\[RFC4379\]](#):

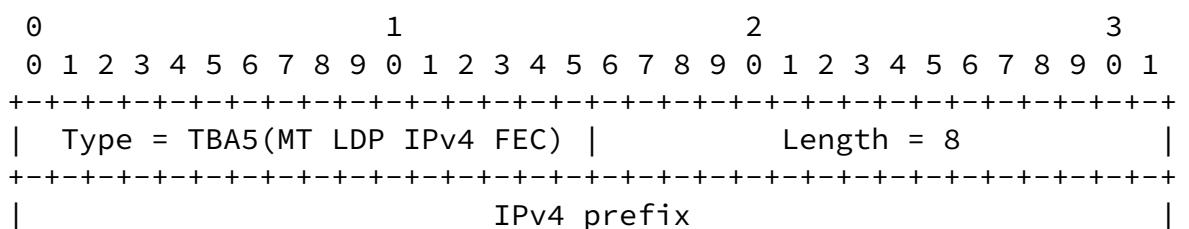
Sub-Type	Length	Value Field
-----	-----	-----
TBA5	5	MT LDP IPv4 prefix
TBA6	17	MT LDP IPv6 prefix

Figure 7: 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:



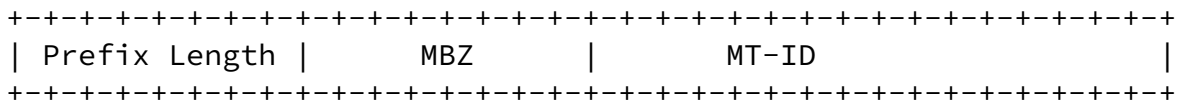


Figure 8: MT LDP IPv4 FEC sub-TLV

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:

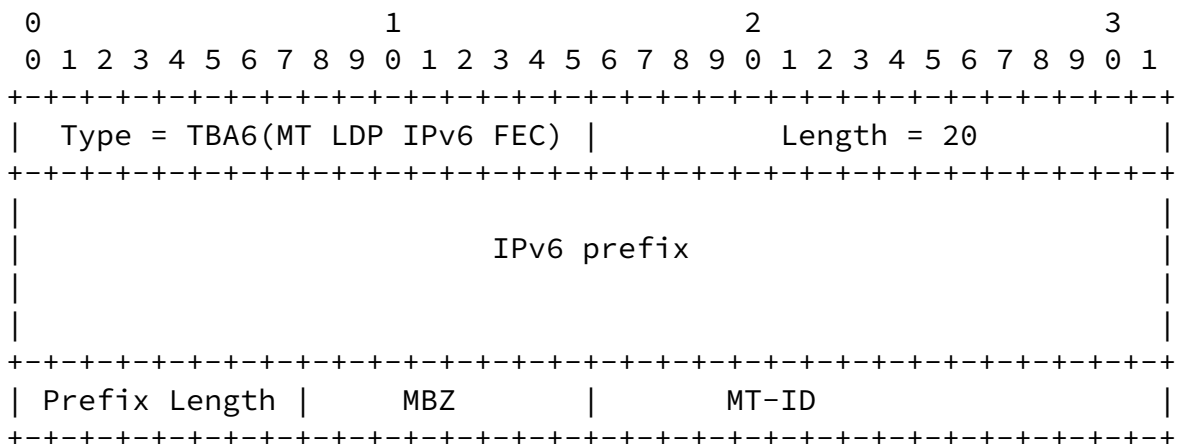


Figure 9: MT LDP IPv6 FEC sub-TLV

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

When 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 binded 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 may go through the default topology instead of the topology where the Echo Request goes through.

### 5. Error Handling

The extensions defined in this document utilise the existing LDP error handling defined in [RFC5036]. If an LSR receives an error notification from a peer for an MPLS-MT 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.

## 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 the specified signaling mechanisms do not provide any way for the data plane to associate a given packet with a context-specific label space.

## 8. Security Consideration

No specific security issues with the proposed solutions are known. The proposed 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").
- o New Status Code: "Invalid Topology ID" (requested code point: TBA3 from LDP registry "Status Code Name Space").
- o New Status Code: "Unknown Address Family" (requested code point: TBA4 from LDP registry "Status Code Name Space").



Range/Value	E	Description
0x00000051	1	Invalid Topology ID

Figure 10: New Status Codes 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 11: Address Family Numbers

- o New registry "LDP Multi-Topology (MT) ID Name Space" under "LDP Parameter" namespace. The registry is defined as:

Range/Value	Name
0	Default Topology (ISIS and OSPF)
1-4095	Unassigned
4096	ISIS IPv6 routing topology (i.e. ISIS MT ID #2)
4097-65534	Reserved (for future allocation)
65535	Wildcard Topology (ISIS or OSPF)

Figure 12: 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
TBA5	MT LDP IPv4 prefix
TBA6	MT LDP IPv6 prefix

Figure 13: New Sub-TLV Types for LSP ping

10. Contributors

Ning So  
Tata Communications  
2613 Fairbourne Cir.  
Plano, TX 75082  
USA

Email: [ning.so@tatacommunications.com](mailto:ning.so@tatacommunications.com)

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

Email: [rtorvi@juniper.net](mailto:rtorvi@juniper.net)

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

Email: [huaimochen@huawei.com](mailto:huaimochen@huawei.com)

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

Email: [emily.chen220@gmail.com](mailto:emily.chen220@gmail.com)

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

Email: [lichenyj@chinamobile.com](mailto:lichenyj@chinamobile.com)

Lu Huang  
China Mobile  
53A, Xibianmennei Ave.  
Xunwu District, Beijing 01719  
China

Email: huanglu@chinamobile.com

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Daniel King  
Old Dog Consulting

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

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

Email: zhenbin.li@huawei.com

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## Authors' Addresses

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

Email: [quintin.zhao@huawei.com](mailto:quintin.zhao@huawei.com)

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

Email: [lufang@cisco.com](mailto:lufang@cisco.com)

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

Email: [czhou@cisco.com](mailto:czhou@cisco.com)

Lianyuan Li

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

Email: lilianyuan@chinamobile.com

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

Email: E-mail: skraza@cisco.com

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