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LDP Extensions for Multi Topology Routing
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Abstract

   Multi-Topology (MT) routing is supported in IP through extension of
   IGP protocols, such as OSPF and IS-IS. It would be advantageous to
   extend Multiprotocol Label Switching (MPLS), using Label Distribution
   Protocol (LDP), to support multiple topologies. These LDP
   extensions, known as Multiple Topology Label Distribution Protocol
   (MT LDP), would allow the configuration of multiple topologies within
   an MPLS LDP enabled network.

   This document describes the protocol extensions required to extend
   the existing MPLS LDP signalling protocol for creating and
   maintaining LSPs in an MT environment.

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Table of Contents

1. Terminology

   Terminology used in this document

      MT-ID: A 12 bit value to represent Multi-Topology ID.

      Default Topology: A topology that is built using the MT-ID value
      0.

      MT topology: A topology that is built using the corresponding
      MT-ID.

1.1. Requirements 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].

2. Introduction

   There are increasing requirements to support multi-topology in MPLS
   network. For example, service providers may want to assign different
   level of service(s) to different topologies so that the service
   separation can be achieved. It is also possible to have an in-band
   management network on top of the original MPLS topology, or maintain
   separate routing and MPLS domains for isolated multicast or IPv6
   islands within the backbone, or force a subset of an address space to
   follow a different MPLS topology for the purpose of security, QoS, or
   simplified management and/or operations.

   OSPF and IS-IS use MT-ID (Multi-Topology Identifier) to identify
   different topologies. For each topology identified by an MT-ID, IGP
   computes a separate SPF tree independently to find the best paths to
   the IP prefixes associated with this topology.

   For IP Prefix FECs that are associated with a specific topology, this
   solution utilizes the use of MT-ID of the topology in LDP. Thus the
   LSP for the given Prefix FEC may be created and maintained along the
   IGP path in this topology if it is needed.

   Maintaining multiple MTs for MPLS network in a backwards-compatible
   manner requires several extensions to the label signaling encoding
   and processing procedures. When a label is associated with an IP
   Prefix FEC, the corresponding FEC element includes both the
   destination prefix (IP address) and the topology it belongs to.

   MT based MPLS in general can be used for a variety of purposes such

as service separation by assigning each service or a group of
services to a topology, where the management, QoS, and security of
the service or the group of the services can be simplified and
guaranteed, in-band management network "on top" of the original MPLS
topology, maintain separate routing and MPLS forwarding domains for
isolated multicast or IPv6 islands within the backbone, or force a
subset of an address space to follow a different MPLS topology for
the purpose of security, QoS or simplified management and/or
operations.

One of the use of the MT based MPLS is where one class of data
requires low latency links, for example Voice over IP (VoIP) data.
As a result such data may be sent preferably via physical landlines
rather than, for example, high latency links such as satellite links.
As a result an additional topology is defined as all low latency
links on the network and VoIP data packets are assigned to the
additional topology. Further possible examples are File Transfer
Protocol (FTP) or Simple Mail Transfer Protocol (SMTP) traffic which
can be assigned to additional topology comprising high latency links,
and Internet Protocol version 4 (IPv4) versus Internet Protocol
version 6 (IPv6) traffic which may be assigned to different topology
or data to be distinguished by the Quality of Service (QoS) assigned
to it.

3. Requirements

MPLS-MT may be used for a variety of purposes such as service
separation by assigning each service or a group of services to a
topology, where the management, QoS and security of the service or
the group of the services can be simplified and guaranteed, in-band
management network "on top" of the original MPLS topology, maintain
separate routing and MPLS forwarding domains for isolated multicast
or IPv6 islands within the backbone, or force a subset of an address
space to follow a different MPLS topology for the purpose of
security, QoS or simplified management and/or operations.

The following specific requirements and objectives have been defined
in order to provide the functionality described above, and facilitate
service provider configuration and operation.

o Deployment of MPLS-MT within existing MPLS networks should be
   possible, with MPLS-MT non-capable nodes existing with MPLS-MT
   capable nodes.

o Minimise configuration and operation complexity of MPLS-MT across
   the network.

   o The MPLS-MT solution SHOULD NOT require data-plane modification.

   o The MPLS-MT solution MUST support multiple topologies. Allowing a
      an MPLS LSP to be established across a specific, or set of,
      multiple topologies.

   o Control and filtering of LSPs using explicitly including or
      excluding multiple topologies MUST be supported.

   o The MPLS-MT solution MUST be capable of supporting QoS mechanisms.

   [Editors Note - We expect these base MPLS-MT protocol requirements to
   be evolved over the next few versions of this document. Note that
   all Editors notes will be deleted before publication of the document]

3.1. Application Scenarios

3.1.1. Simplified Data-plane

   IGP-MT requires additional data-plane resources maintain multiple
   forwarding for each configured MT. On the other hand, MPLS-MT does
   not change the data-plane system architecture, if an IGP-MT is mapped
   to an MPLS-MT. In case MPLS-MT, incoming label value itself can
   determine an MT, and hence it requires a single NHLFE space. MPLS-MT
   requires only MT-RIBs in the control-plane, no need to have MT-FIBs.
   Forwarding IP packets over a particular MT requires either
   configuration or some external means at every node, to maps an
   attribute of incoming IP packet header to IGP-MT, which is additional
   overhead for network management. Whereas, MPLS-MT mapping is
   required only at the ingress-PE of an MPLS-MT LSP, because of each
   node identifies MPLS-MT LSP switching based on incoming label, hence
   no additional configuration is required at every node.

3.1.2. Using MT for p2p Protection

   We know that [IP-FRR-MT] can be used for configuring alternate path
   via backup-mt, such that if primary link fails, then backup-MT can be
   used for forwarding. However, such techniques require special
   marking of IP packets that needs to be forwarded using backup-MT.
   MPLS-LDP-MT procedures simplify the forwarding of the MPLS packets
   over backup-MT, as MPLS-LDP-MT procedure distribute separate labels
   for each MT. How backup paths are computed depends on the
   implementation, and the algorithm. The MPLS-LDP-MT in conjunction
   with IGP-MT could be used to separate the primary traffic and backup
   traffic. For example, service providers can create a backup MT that
   consists of links that are meant only for backup traffic. Service
   providers can then establish bypass LSPs, standby LSPs, using backup
   MT, thus keeping undeterministic backup traffic away from the primary

   traffic.

3.1.3. Using MT for mLDP Protection

   Fro the P2mP or MP2MP LSPs setup by using mLDP protocol, there is a
   need to setup a backup LSP to have an end to end protection for the
   priamry LSP in the appplicaitons such IPTV, where the end to end
   protection is a must. Since the mLDP lSp is setup following the IGP
   routes, the second LSP setup by following the IGP routes can not be
   guranteed to have the link and node diversity from the primary LSP.
   By using MPLS-LDP-MT, two topology can be configured with complete
   link and node diversity, where the primary and secondary LSP can be
   set up independantly within each topology. The two LSPs setup by
   this mechanism can protect each other end-to-end.

3.1.4. Service Separation

   MPLS-MT procedures allow establishing two distinct LSPs for the same
   FEC, by advertising separate label mapping for each configured
   topology. Service providers can implement CoS using MPLS-MT
   procedures without requiring to create separate FEC address for each
   class. MPLS-MT can also be used separate multicast and unicast
   traffic.

3.1.5. An Alternative inter-AS VPN Solution

   When the lsp is crossing multiple domains for the inter-as VPN
   scenarios, the LSP setup process can be done by configuring a set of
   routers which are in different domains into a new single domain with
   a new topology ID using the LDP multiple topology. All the routers
   belong this new topology will be used to carry the traffic across
   multiple domains and since they are in a single domain with the new
   topology ID, so the LDP lsp set up can be done without propagating
   VPN routes across AS boundaries.

3.2. Signaling Extensions

3.2.1. Topology-Scoped Prefix FEC

   LDP assigns and binds a label to a FEC, where a FEC is a list of one
   of 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 Multi-Topology LSPs for IP prefixes under a given topology
   scope, it is a natural requirement to extend LDP "Prefix" FEC element
   to include topology info. This infers that MT-ID becomes an
   attribute of Prefix FEC element, and all FEC-Label binding operations
   are performed under the context of given topology (MT-ID). Following

subsection proposes the extension to bind "Prefix FEC" to a topology.

3.2.1.1. New Address Families: MT IP

LDP base specification [RFC5036] (section 3.4.1) defines the "Prefix"
FEC Element as follows:

```
   0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |  Prefix (2)   |     Address Family            |    PreLen     |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                       Prefix                                  |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
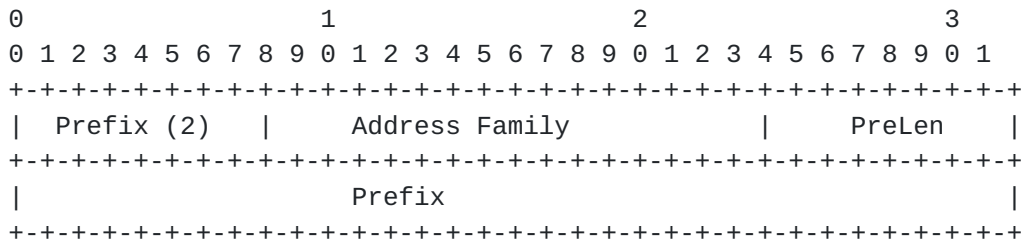
            Figure 1: Prefix FEC Element Format [RFC5036]

Where "Prefix" encoding is as defined for given "Address Family", and
whose length (in bits) is specified by the "PreLen" field.

To extend IP address families for MT, we propose two new Address
Families named "MT IP" and "MT IPv6" that can be used to specify IP
prefixes within a topology scope. The format of data associated with
these new Address Family is:

```
   0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                       (IP) Prefix                             |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |           Reserved            |          MT-ID                |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
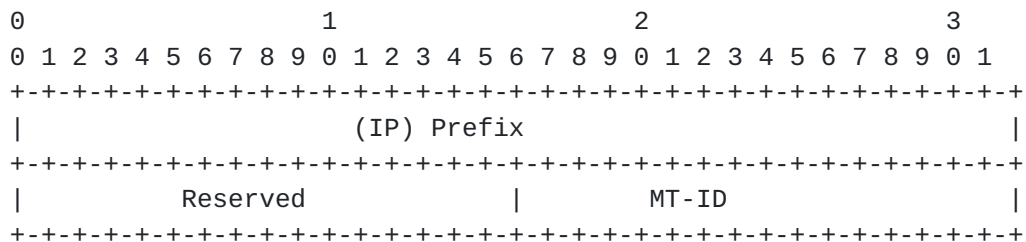
              Figure 2: MT IP Address Family Format

Where "(IP) Prefix" 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 prefix.

For MT LDP, the "Prefix" FEC element's "Address Family" will be set
to "MT IP" or "MT IPv6", and the FEC element will be encoded as
follows:

```
  0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | Prefix (2)  | Address Family (MT IP/MT IPv6)|    PreLen     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                          Prefix                              |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |            Reserved           |            MT-ID             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
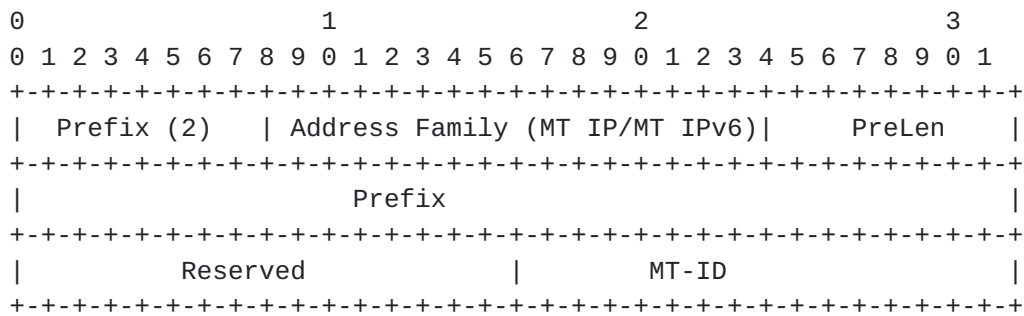
               Figure 3: MT Prefix FEC Element Format

   Where 16-bit "MT-ID" field defines the Topology ID, and the
   definition and usage of "Prefix" and "PreLen" field is 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 "Prefix FEC Element" with "MT IP" Address Family can be
   used in any LDP message and procedures that currently specify and
   allow the use of "Prefix FEC" element with IP/IPv6 Address Family.

   This document does not limit the use of these new AF only to LDP
   "Prefix FEC element", and these can be used in other FECs and
   signaling as required. For example, mLDP MP FECs, as specified in
   [mLDP], can be extended to use these new address families to make MP
   FECs to become MT aware.

   [Editors Note - RFC[5036] doesn't specify the handling of unknown
   Address Family. After we have introduced the two new address family
   here, RFC[5036] need to be updated to add the handling procedure for
   the unknow address families.

3.2.1.2. IGP MT-ID Mapping and Translation

   The non-reserved non-special IGP MT-ID values can be used/carried in
   LDP as-is and need no translation. However, there is a need for
   translating reserved/special IGP MT-ID values to corresponding LDP
   MT-IDs. The corresponding special/reserved LDP MT-ID values are
   defined in later section 9.

3.2.2. 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

MTR for 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 Prefix FEC Element" as defined in [RFC5918].

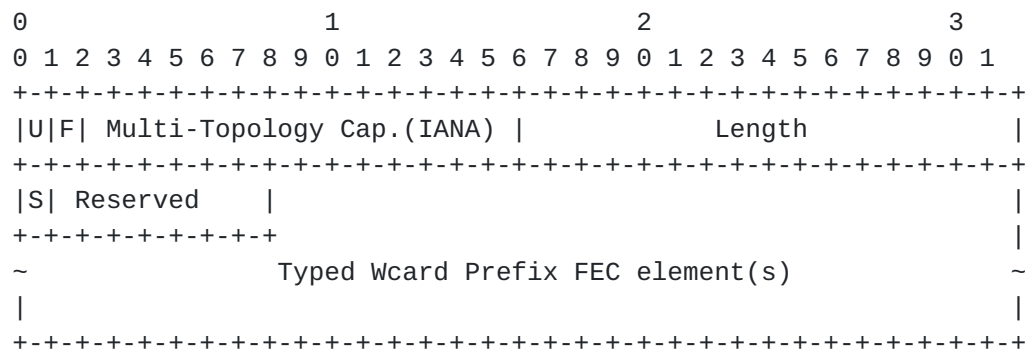The format of "Multi-Topology Capability" TLV is as follows:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |U|F| Multi-Topology Cap.(IANA) |            Length             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |S| Reserved    |                                               |
 +-+-+-+-+-+-+-+-+                                               |
 ~              Typed Wcard Prefix FEC element(s)               ~
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Multi-Topology Capability TLV Format

Where:

U- and F-bits: MUST be 1 and 0, respectively, as per Section 3 of LDP
Capabilities [RFC5561].

Multi-Topology Capability: Capability TLV type (IANA assigned)

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.

Typed Wcard Prefix FEC element(s): One or two elements specified as
the "Capability data".

Length: The length (in octets) of TLV. The value of this field MUST
be 6 with one FEC element specification, and 11 for two FEC element
specifications.

The encoding of Typed Wcard Prefix FEC element, as defined in
[RFC5561], is as follows:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Typed Wcard (5)|Type=Prefix (2)|   Len = 2     | Address...    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...Family     |
+-+-+-+-+-+-+-+-+
```

Figure 5: Typed Wildcard Prefix FEC Element [RFC5561]

Where:

Address Family: MUST be set to "MT IP" or "MT IPv6"

3.2.3. Procedures

To announce its MT capability for given IP address family, an LDP
speaker MAY send "MT Capability" with exactly one Typed Wildcard
Prefix FEC element with corresponding "Address Family" field (i.e.
set to "MT IP" for IPv4 and set to "MT IPv6" for IPv6 address
family). To announce its MT capability for both IPv4 and IPv6
address family, an LDP speaker MAY send "MT Capability" with two
Typed Prefix FEC elements in it, where Address Family is set to "MT
IP" in one element and set to "MT IPv6" in other element.

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
   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 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 We propose 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 MT capable to non-MT capable, it may
   initiate withdraw of all label mapping for existing LSPs of all
   non-default MTs. Alternatively, it may wait until the routing
   update to withdraw FEC and release the label mapping for existing
   LSPs of specific MT.

o There will be case where IGP is MT capable but MPLS is not and the
   handling procedure for this case is TBD.

3.2.4. LDP Sessions

Depending on the number of label spaces supported, if a single global
label space is supported, there will be one session supported for
each pair of peer, even there are multiple topologies supported
between these two peers. If there are different label spaces
supported for different topologies, which means that label spaces
overlap with each other for different MTs, then it is suggested to
establish multiple sessions for multiple topologies between these two
peers. In this case, multiple LSR-IDs need to be allocated
beforehand so that each multiple topology can have its own label
space ID.

[Editors Note - This section requires further discussion]

3.2.5. Reserved MT ID Values

Certain MT topologies are assigned to serve pre-determined 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.

We propose a new IANA registry "LDP Multi-Topology ID Name Space"
under IANA "LDP Parameter" namespace to keep 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.

[Editors Note - This section requires further discussion].

3.3. MT Applicability on FEC-based features

3.3.1. Typed Wildcard Prefix FEC Element

RFC-5918 extends base LDP and defines Typed Wildcard FEC Element
framework [RFC5918]. 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
in procedures for Typed Wildcard Prefix FEC element, and these
procedures apply as-is to MT Prefix wildcarding. The MT extensions,
though, allow use of "MT IP" or "MT IPv6" in the Address Family field
of the Typed Wildcard Prefix 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.

This document extends Typed Wildcard Prefix FEC element encoding for
MT is as follows:

```
0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |Typed Wcard (5)|Type=Prefix (2)|   Len = 4     |  AF = MT IP ..|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |... or MT IPv6 |     MT-ID                     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

              Figure 6: Typed Wildcard Prefix FEC Element for MT

The proposed format 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 "Wildcard
Topology" MT-ID as defined in section 5.4. For instance, upon local
un-configuration of topology "x", an LSR may send wildcard label
withdraw with MT-ID "x" to withdraw all its labels from peer that
were advertised under the scope of topology "x". On the other hand,
upon some global configuration change, an LSR may send wildcard label
withdraw with MT-ID set to "Wildcard Topology" to withdraw all its
labels under all topologies from the peer.

3.3.2. End-of-LIB

[RFC5919] specifies extensions and procedures for an LDP speaker to
signal its convergence for given FEC type towards a peer. The
procedures defined in [RFC5919] apply as-is to MT Prefix FEC element.
This means that an LDP speaker MAY signal its IP convergence using

Typed Wildcard Prefix FEC element, and its MT IP convergence per
topology using MT Typed Wildcard Prefix FEC element (as defined in
earlier section).

[3.4](#). 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.

[3.5](#). Security Consideration

No specific security issues with the proposed solutions are known.
The proposed extension in this document does not introduce any new
security considerations beyond that already apply to the base LDP
specification [[RFC5036](#)] and [[RFC5920](#)].

[3.6](#). 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: 0x510 from LDP registry "TLV Type Name Space").

o   New Status Code: "Invalid Topology ID" (requested code point: 0x50
    from LDP registry "Status Code Name Space") as follows:

```
      Registry:
      Range/Value     E     Description
      -------------   ---   ------------------------------
      0x00000050      0     Invalid MT-ID
```

                    Figure 7: Invalid Topology ID

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 8: 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 9: LDP Multi-Topology (MT) ID Name Space

3.7. Acknowledgement

   The authors would like to thank Dan Tappan, Nabil Bitar, Huang Xin,
   Daniel King and Eric Rosen for their valuable comments on this draft.

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4.1. Normative References

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