TRILL: Multi-Topology
<draft-eastlake-trill-multi-topology-00.txt>

Abstract

   This document specifies extensions to the IETF TRILL (Transparent
   Interconnection of Lots of Links) protocol to support multi-topology
   routing of unicast and multi-destination traffic based on IS-IS
   (Intermediate System to Intermediate System) multi-topology specified
   in RFC 5120. It updates RFC 6325 and updates RFC 6327bis.

Status of This Memo

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[1](#). **Introduction**

   This document specifies extensions to the IETF TRILL (Transparent
   Interconnection of Lots of Links) protocol [[RFC6325](#)] [[RFC6326bis](#)]
   [[RFC6327bis](#)] to support multi-topology routing for both unicast and
   multi-destination traffic based on IS-IS (Intermediate System to
   Intermediate System, [[IS-IS](#)] [[RFC1195](#)]) multi-topology [[RFC5120](#)].
   Implementation and use of multi-topology are optional and use
   requires configuration. It is anticipated that not all TRILL campuses
   will need or use multi-topology.

   Multi-topology creates different physical topologies or overlays on
   top of a single physical TRILL campus topology. This is different
   from Data Labels (VLANs and Fine Grained Labels [[RFCfgl](#)]). Data
   Labels specify communities of end stations and can be viewed as
   creating virtual topologies of end station connectivity. However, in
   a single topology TRILL campus, TRILL Data packets can use any part
   of the physical topology of TRILL switches and links between them,
   regardless of the Data Label of that packet's payload. In a multi-
   topology TRILL campus, TRILL data packets in a topology are
   restricted to the physical TRILL switches and links that are in their
   topology but may use any of those TRILL switches and links regardless
   of the Data Label of their payload.

   The essence of multi-topology behavior is that a multi-topology
   router classifies packets as to the topology within which they should
   be routed and uses logically different routing tables for different
   topologies. If routers in the network do not agree on the topology
   classification of packets or links, persistent routing loops can
   occur.

   The multi-topology TRILL extensions can be used for a wide variety of
   purposes, such as maintaining separate routing domains for isolated
   multicast or IPv6 islands, making a class of traffic avoid certain
   TRILL switches that lack some characteristic needed by that traffic,
   or making a class of traffic avoid certain links due to security,
   reliability, or other concerns.

   It is possible for a particular topology to not be fully connected
   resulting in two or more islands of that topology. In that case, end
   station connected in that topology to different islands will be
   unable to communicate with each other.

   Multi-topology TRILL supports regions of topology ignorant TRILL
   switches as part of an multi-topology campus; however, such regions
   can only ingress, egress, or transit TRILL Data frames in the special
   base topology zero.

1.1 Terminology

The terminology and acronyms of [RFC6325] are used in this document
along with the following:

    FGL - Fine-Grained Labeling or Fine-Grained Labeled or Fine-
        Grained Label [RFCfgl].

    MT - Multi-Topology, this document and [RFC5120].

    MT TRILL Switch - A FGL TRILL switch supporting the multi-topology
        feature specified in this document.

    RBridge - "Routing Bridge", an alternative name for a TRILL
        switch.

    TRILL Switch - A switch implementing the TRILL protocol [RFC6325]
        [RFC6326bis] [RFC6327bis].

    VL - VLAN Labeling or VLAN Labeled or VLAN Label [RFCfgl].

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 [RFC2119].

[2](). **Topologies**

   In TRILL multi-topology, a topology is a subset of the TRILL switches
   and of the links between TRILL switches in a TRILL campus. TRILL Data
   packets are constrained to the subset of switches and links
   corresponding to the packet's topology. TRILL multi-topology is based
   on [[RFC5120]()] IS-IS multi-topology. See [Appendix A]() for differences
   between TRILL multi-topology and [[RFC5120]()].

   The zero topology is special as described in [Section 2.1](). Sections
   2.2, 2.3, and 2.4 discuss the topology of links, TRILL switches, and
   TRILL Data packets respectively.

[2.1]() **Special Topology Zero**

   The zero topology is special as the default base topology. All TRILL
   switches and links are considered to be in and MUST support topology
   zero. Thus, for example, topology zero can be used for general TRILL
   switch access within a campus for management messages, BFD messages
   [[RFCbfd]()], other RBridge Channel messages [[RFCchannel]()], and the like.

[2.2]() **Links and Multi-Topology**

   Multi-topology TRILL switches advertise the topologies for which they
   are willing to send and received TRILL Data packets on a port by
   listing those topologies in one or more MT TLVs [[RFC5120]()] appearing
   in every TRILL Hello [[RFC6327bis]()] they send out that port except that
   they MUST handle topology zero, which it is optional to list.

   A link is only usable for TRILL Data packets in non-zero topology T
   if (1) all TRILL switch ports on the link advertise topology T
   support in their Hellos and (2) if any TRILL switch port on the link
   requires explicit TRILL Data packet topology labeling (see [Section
   2.4]()) every other TRILL switch port on the link is capable of
   generating explicit packet topology labeling.

[2.3]() **TRILL Switches and Multi-Topology**

   A TRILL switch advertises the topologies that it supports by listing
   them in one or more MT TLVs [[RFC5120]()] in its LSP except that it MUST
   support topology zero which is optional to list.

   There is no general "MT capability bit". A TRILL switch advertises

that it is MT capable by advertising in its LSP support for any

topology or topologies with the MT TLV, even if it just explicitly
advertises support for topology zero.

2.4 TRILL Data Packets and Multi-Topology

Commonly, the topology of a TRILL Data packet is determined from
either (1) some field or fields present in the packet itself or (2)
the port on which the packet was received; however optional explicit
topology labeling of TRILL Data packets is also proved. This can be
included in the data labeling area of TRILL Data packets as specified
below.

Examples of fields sometimes used to determine topology are values or
ranges of values of the payload VLAN or Fine Grained Label [RFCfgl],
packet priority, IP version (IPv6 versus IPv4) or IP protocol,
Ethertype, unicast versus multi-destination payload, IP
Differentiated Services Code Point (DSCP) bits, or the like.

"Multi-topology" does not apply to TRILL IS-IS packets or to link
level control frames. Those message are link local and can be thought
of as being outside all topologies. "Multi-topology" only applies to
TRILL Data packets.

2.4.1 Explicit Topology Labeling Support

Support of the explicit topology label is optional even for MT TRILL
switches. Support could depend on port hardware and is indicated by
a two-bit capability field in the Port TRILL Version sub-TLV
[RFC6326bis] appearing in the Port Capabilities TLV in Hellos. If
there is no Port TRILL Capabilities sub-TLV in a Hello, then it is
assumed that explicit topology labeling is not supported on that
port. See the table below for the meaning of values of the Explicit
Topology capability field:

```
   Value   Meaning
   -----   -------
     0   No support. Cannot send TRILL Data packets with an explicit
         topology label and should treat as erroneous and discard any
         data packet received with a topology label.
     1   Capable of inserting an explicit topology label in data
         packets sent and tolerant of such labels in received data
         packets. Such a port is capable of determining TRILL Data
         packet topology without an explicit lable and thus does not
         require such a label in received TRILL Data packets. On
         receiving a packet whose explicit topology label differs from
```

the ports topology determination for that packet, the TRILL

               switch MUST discard the packet.
2/3 Requires an explicit topology label in received TRILL Data packets
         except for topology zero. Any TRILL Data packets received
         without such a label is classified as being in topology zero.
         Also capable of inserting an explicit topology label in TRILL
         Data packets sent. (Values 2 and 3 are treated the same,
         which is the same as saying that if the 2 bit is on, the 1
         bit is ignored.)

   A TRILL switch advertising in a Hello on Port P support for topology
   T but not advertising in those Hellos that it requires explicit
   topology labeling is assumed to have the ability and configuration to
   correctly classify TRILL Data packets into topology T by examination
   of those TRILL Data packets or by using the fact that they are
   arriving at port P.

   When a TRILL switch transmits a TRILL Data packet onto a link, if any
   other TRILL switch on that link requires explicit topology labeling,
   an explicit topology label MUST be included. If a label is not so
   required but all other TRILL switches on that link support explicit
   topology labeling, then such a label MAY be included.

2.4.2 Explicit Topology Labels

   The TRILL MT label is structured 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    TRILL-MT Ethertype TBD      | RESV  |         MT-ID         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                     Figure 1. TRILL MT Label

   where RESV is a 4-bit reserved field that MUST be sent as zero and
   ignored on receipt and MT-ID is the 12-bit topology of the TRILL Data
   packet using the topology number space of the MT TLV [RFC5120]. With
   the addition of the TRILL MT label, the four standardized content
   varieties for the TRILL Data packet data labeling area (the area
   after the Inner.MacSA and before the payload) are as show below.
   {PRI, D} is a 3-bit priority and a drop eligibility indicator bit
   [RFCclear]. All MT TRILL switches MUST support FGL and thus MUST
   support all four data labeling area contents shown below.

1. C-VLAN [RFC6325]

```
                        1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0x8100                      | PRI |D|  VLAN ID               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

2. FGL [RFCfgl]

```
                        1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0x893B                      | PRI |D|  FGL Upper Part        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0x893B                      | PRI |D|  FGL Lower Part        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

3. MT C-VLAN [this document]

```
                        1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   TRILL-MT Ethertype TBD      | RESV |   MT-ID                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0x8100                      | PRI |D|  VLAN ID               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

4. MT FGL [this document] [RFCfgl]

```
                        1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   TRILL-MT Ethertype TBD      | RESV |   MT-ID                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0x893B                      | PRI |D|  FGL Upper Part        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0x893B                      | PRI |D|  FGL Lower Part        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Inclusion of S-VLAN or other stacked tags is beyond the scope of this
document but, as stated in [RFC6325], is an obvious extension.

3. TRILL Multi-Topology Adjacency and Routing

   Routing calculations in IS-IS are based on adjacency. Section 3.1
   specifies multi-topology updates to the TRILL adjacency
   specification. Section 3.2 describes the handling of nicknames.
   Sections 3.3 and 3.4 specify how unicast and multi-destination TRILL
   multi-topology routing differ from the TRILL base protocol.

3.1 Adjacency (Updates to RFC 6327bis)

   There is no change in the determination or announement of adjacency
   for topology zero as specified in [RFC6327bis]. When an adjacency
   reaches the Report state as specified in [RFC6327bis], the adjacency
   is announced for topology zero in LSPs using the Extended
   Intermediate System Reachability TLV (#22).

   Adjacency is announced for non-zero topologies in LSPs using the MT
   Reachable Intermediate Systems TLV as specified in [RFC5120]. The
   ports on a TRILL link are reported in LSPs adjacencies for non-zero
   topology T if and only if that adjacency is in the Report state
   [RFC6327bis] and the two conditions listed in Section 2.2 are true,
   namely:

   1. All the ports on the link are announcing support of topology T.

   2. If any port announces that it requires explicit topology labeling
      (Explicit Topology capability field value 2 or 3), all other ports
      advertise that they are capable of producing such labeling
      (Explicit Topology capability field value of 1, 2, or 3).

3.2 TRILL Switch Nicknames

   TRILL switches are usually identified within the TRILL protocol (for
   example in the TRILL Header) by nicknames [RFC6325] [RFCclear]. Such
   nicknames can be viewed as simply 16-bit abbreviation for a TRILL
   switch's or pseudo-node's 7-byte IS-IS ID. A TRILL switch or pseudo-
   node can have more than one nickname, each of which identifies it.

   Nicknames are common across all topologies, just as IS-IS IDs are.
   Nicknames are determined as specified in [RFC6325] and [RFCclear]
   using only the Nickname sub-TLVs appearing in Router Capabilities
   TLVs (#242) in the LSPs of TRILL switches. In particular, the
   nickname allocation algorithm ignores Nickname sub-TLVs that appear
   in MT Router Capability TLVs (#144). (However, nickname sub-TLVs that
   appear in MT Router Capability TLVs with a non-zero topology do

affect the choice of distribution tree roots as described in Section

3.4.1.)

To minimize transient inconsistencies, all Nickname sub-TLVs
advertised by a TRILL switch for a particular nickname, whether in
Router Capability or MT Router Capability TLVs, SHOULD appear in the
same LSP. If that is not the case, then all LSPs in which they do
occur should be flooded as an atomic action.

3.3 TRILL Unicast Routing

TRILL Data packets being TRILL unicast (those with TRILL Header M bit
= 0) are routed based on the egress nickname using logically separate
forwarding tables per topology where each such table has been
calculated based on least cost routing within the particular
topology. Thus, the next hop when forwarding TRILL Data packets is
determined by a lookup logically based on {topology, egress
nickname}.

3.4 TRILL Multi-Destination Routing

TRILL sends multi-destination data packets (those packets with TRILL
Header M bit = 1) over a distribution tree. Trees are designated by
nicknames that appear in the "egress nickname" field of multi-
destination TRILL Data packets. To constrain multi-destination
packets to a topology and still distribute them properly requires the
use of a distribution tree constrained to that topology. Handling
such TRILL Data packets and distribution trees in MT is as described
in the subsections below.

3.4.1 Distribution Trees

General provisions for distribution trees and how those trees are
determined are as specified in [RFC6325], [RFCclear], and [RFCfgl].
The distribution trees for topology zero are determined as specified
in those references and are the same as they would be with topology-
ignorant TRILL switches.

The TRILL distribution tree construction and packet handling for some
non-zero topology T are determine as specified in [RFC6325],
[RFCclear], and [RFCfgl] with the following changes:

   o As specified in [RFC5120], only links usable with topology T
      TRILL Data frames are considered when building a distribution

tree for topology T. As a result, such trees are automatically

      limited to and separately span every internally connected
      island of topology T. In other words, if non-zero topology T
      consists of disjoint islands, distribution tree construction
      for topology T is local to each such island.

   o Only the Nickname sub-TLV, Trees sub-TLV, Tree Identifiers sub-
      TLV, and Trees Used sub-TLV occurring in an MT Router
      Capabilities TLV (#144) specifying topology T are used in
      determining the tree root(s), if any, for topology T.

      + There may be non-zero topologies with no multi-destination
         traffic. For example, if only known destination unicast IPv6
         TRILL Data packets were in topology T and multi-destination
         IPv6 TRILL Data packets were in some other topology, there
         would be no need for a distribution tree for topology T.
         For this reasons, a Number of Trees to Compute of zero in
         the Trees sub-TLV for the TRILL switch holding the highest
         priority to be a tree root for a non-zero topology T is
         honored and causes no distribution trees to be calculated
         for non-zero topology T. This is different from the base
         topology zero where, as specified in [RFC6325], a zero
         Number of Trees to Compute causes one tree to be computed.

   o Nicknames are allocated as described in Section 3.2. If a
      TRILL switch advertising that it provides topology T service
      holds nickname N, the priority of N to be a tree root is given
      by the tree root priority field of the Nickname sub-TLV that
      has N in its nickname field and occurs in a topology T MT
      Router Capabilities TLV advertised by that TRILL switch. If no
      such Nickname sub-TLV can be found, the priority of N to be a
      tree root is the default for an FGL TRILL switch as specified
      in [RFCfgl].

      + There could be multiple topology T Nickname sub-TLVs for N
         being advertised for a particular RBridge or pseudo-node,
         due to transient conditions or errors. In that case, the one
         in the lowest numbered LSP fragment is used and if there are
         multiple in that fragment, the one with the smallest offset
         from the beginning of the LSP is used.

   o Tree pruning for topology T uses only the Interested VLANs and
      Interested Labels sub-TLVs [RFC6326bis] advertised in MT Router
      Capabilities TLVs for topology T.

   An MT TRILL switch MUST have logically separate routing tables per
   topology for the forwarding of multi-destination traffic.

3.4.2 Multi-Access Links

Multi-destination TRILL Data packets are forwarded on broadcast
(multi-access) links in such a way as to be received by all other
TRILL switch ports on the link. For example, on Ethernet links they
are sent with a multicast Outer.MacDA [RFC6325]. Care must be taken
that a TRILL Data packet in a non-zero topology is only forwarded by
an MT TRILL switch.

For this reason, a non-zero topology TRILL Data packet MUST NOT be
forwarded onto a link unless the link meets the requirements
specified in Section 2.2 for use in that topology even if there are
one or more MT TRILL switch ports on the link.

[4](#). Mixed Links

A link might have any combination of MT, FGL, or even VL TRILL
switches on it [[RFCfgl](#)]. DRB (Designated RBridge) election and
Forwarder appointment on the link work as previously specified in
[[RFC6439](#)] and [[RFC6327bis](#)]. It is up to the network manager to
configure and manage the TRILL switches on a link so that the desired
switch is DRB and the desired switch is the Appointed Forwarder for
the appropriate VLANs.

Frames ingressed by MT TRILL switches can potentially be in any
topology recognized by the switch and permitted on the ingress port.
Frames ingressed by VL or FGL TRILL switches can only be in the base
zero topology. Because FGL and VL TRILL switches do not understand
topologies, all occurrences of the following sub-TLVs MUST occur only
in MT Port Capability TLVs with a zero MT-ID. Any occurrence of these
sub-TVLs in an MT Port Capability TLV with a nonzero MT-ID is
ignored.

        Special VLANs and Flags Sub-TLV
        Enabled-VLANs Sub-TLV
        Appointed Forwarders Sub-TLV
        VLANs Appointed Sub-TLV

Native frames cannot be explicitly labeled (see [Section 2.4](#)) as to
their topology.

5. Other Multi-Topology Considerations

5.1 Address Learning

   The learning of end station MAC addresses is per topology as well as
   per label (VLAN or FGL). The same MAC address can occur for different
   end stations that differ only in topology.

5.1.1 Data Plane Learning

   End station MAC addresses learned from ingressing native frames or
   egressing TRILL Data packets are, for MT TRILL switches, qualified by
   topology, that is, either the topology into which that TRILL switch
   classified the ingressed native frame or the topology with which the
   egressed TRILL Data frame was explicitly labeled.

5.1.2 Multi-Topology ESADI

   In an MT TRILL switch, ESADI [RFCesadi] operates per label (VLAN or
   FGL) per topology. Since ESADI messages appear, to transit TRILL
   switches, like normal multi-destination TRILL Data packets, ESADI
   link state databases are per topology as well as per label and local
   to each area of multi-destination TRILL data connectivity for that
   topology.

5.2 Legacy Stubs

   Areas of topology ignorant TRILL switches can be connected to and
   become part of an MT TRILL campus but will only be able to ingress,
   transit, or egress topology zero TRILL Data packets.

5.3 RBridge Channel Messages

   RBridge Channel messages [RFCchannel], such as BFD over TRILL
   [RFCbfd] appear, to transit TRILL switches, like normal multi-
   destination TRILL Data packets. Thus, they have a topology and are
   constrained by topology like other TRILL Data packets. In general,
   when sent for network management purposes, they are sent in topology
   zero.

5.4 Implementations Considerations

MT is an optional TRILL switch capability.

Experience with the actual deployment of Layer 3 IS-IS MT [RFC5120]
indicates that a single router handling more than eight topologies is
rare. There may be many more than eight distinct topologies in a
routed area but in that case many of these topologies will be handled
by disjoint sets of routers.

Based on this deployment experience, a TRILL switch capable of
handling 16 or more topologies can be considered a full
implementation while a TRILL switch capable of handling 4 topologies
can be considered a minimal implementation but still useful under
some circumstances.

6. Allocation Considerations

IEEE Registration Authority and IANA considerations are given below.

6.1 IEEE Registration Authority Considerations

The IEEE Registration Authority will be requested to allocate a new Ethertype for TRILL-MT (see Section 2.4).

6.2 IANA Considerations

IANA will allocate a 2 bit field TBD from bits 14 through 31 of the Capabilities bits of the Port TRILL Version Sub-TLV for the Explicit Topology capability field.

[7](#). Security Considerations

Multiple topologies are sometimes used for the isolation or security
of traffic. For example, if some links was more likely than others to
be subject to adversarial observation it might be desirable to
classify certain sensitive traffic in a topology that excluded those
links.

For general TRILL security considerations, see [[RFC6325](#)].

Acknowledgements

The comments and suggestions of the following are gratefully
acknowledged:

    TBD

The document was prepared in raw nroff. All macros used were defined
within the source file.

Normative References

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Informative References

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    [RFCbfd] - V. Manral, D. Eastlake, D. Ward, A. Banerjee, "TRILL:
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Appendix A: Differences from RFC 5120

   This document differs from RFC 5120 as follows:

   1. [RFC5120] provides for unicast multi-topology. This document
      extends that to cover multi-destination TRILL data distribution
      (see Section 3.4).

   2. [RFC5120] assumes the topology of data packets is always
      determined implicitly, that is, based on the port over which the
      packets are received or pre-existing fields within the packet.
      This document supports implicit determination but extends this for
      TRILL by providing for optional explicit topology labeling of
      TRILL Data packets (see Section 2.4).

   3. [RFC5120] makes support of the default topology zero optional for
      MT routers and links. For ease and simplicity in network
      management, this document requires all TRILL switches and links
      between TRILL switches to support topology zero (see Section 2.1).

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