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TRILL: Multi-Topology
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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 RFC 7177.

Status of This Memo

Distribution of this document is unlimited. Comments should be sent to the TRILL working group mailing list.

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1. Introduction

This document specifies extensions to the IETF TRILL (Transparent Interconnection of Lots of Links) protocol [RFC6325] [RFC7176] [RFC7177] to support multi-topology routing for both unicast and multi-destination traffic based on IS-IS (Intermediate System to Intermediate System, [IS-IS]) 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 topologies or subsets from a single physical TRILL campus topology. This is different from Data Labels (VLANs and Fine Grained Labels [RFC7172]). 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 TRILL switches, 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 still use any of the TRILL switches and links in their topology 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, routing a class of traffic so that it avoids 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:

campus - The name for a TRILL network, like "bridged LAN" is a name for a bridged network. It does not have any academic implication.

FGL - Fine-Grained Labeling or Fine-Grained Labeled or Fine-Grained Label [RFC7176].

LSP - [IS-IS] Link State PDU (Protocol Data Unit). For TRILL this include L1-LSPs and E-L1FS-LSPs [rfc7180bis].

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 - Transparent Interconnecton of Lots of Links or Tunneled Routing in the Link Layer [RFC6325].

TRILL Switch - A switch implementing the TRILL protocol.

VL - VLAN Labeling or VLAN Labeled or VLAN Label [RFC7172].

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 [RFC7175], RBridge Channel messages [RFC7178], 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 [RFC7177] 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 that may sometimes used to determine topology are values or ranges of values of the payload VLAN or Fine Grained Label [RFC7172], 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 [RFC7176] 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 for all of the topologies it supports 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 [rfc7180bis]. 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 [RFC7172]

```
                        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 High Part        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  0x893B                       | PRI |D|  FGL Low 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] [RFC7172]

```
                        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 High Part        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  0x893B                       | PRI |D|  FGL Low 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 7177)

There is no change in the determination or announement of adjacency for topology zero as specified in [RFC7177]. When an adjacency reaches the Report state as specified in [RFC7177], 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 as adjacent for non-zero topology T if and only if that adjacency is in the Report state [RFC7177] 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] [rfc7180bis]. 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 [rfc7180bis] using only the Nickname sub-TLVs appearing in Router Capabilities TLVs (#242) advertised by 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], [rfc7180bis], and [RFC7172]. 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], [rfc7180bis], and [RFC7172] 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.

- 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 all 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.

- 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 [RFC7172].

  + 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.

- Tree pruning for topology T uses only the Interested VLANs and Interested Labels sub-TLVs [RFC7176] 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 [RFC7172]. DRB (Designated RBridge) election and Forwarder appointment on the link work as previously specified in [RFC6439] and [RFC7177]. 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 that the egressed TRILL Data frame was in.

5.1.2 Multi-Topology ESADI

In an MT TRILL switch, ESADI [RFC7357] 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 [RFC7178], such as BFD over TRILL [RFC7175] 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, such as a TRILL campus, but in that case many of these topologies will be handled by disjoint sets of routers and/or links.

Based on this deployment experience, a TRILL switch capable of handling 8 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 field of two adjacent bits 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.

Delivery of data originating in one topology outside of that topology is generally a security policy violation to be avoided at all reasonable costs.

For general TRILL security considerations, see [RFC6325].

Normative References

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[RFC7175] - Manral, V., Eastlake 3rd, D., Ward, D., and A. Banerjee, "Transparent Interconnection of Lots of Links (TRILL): Bidirectional Forwarding Detection (BFD) Support", RFC 7175, May 2014.

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.

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 simplicity and ease 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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