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TRILL Use of IS-IS
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Abstract

   The IETF has standardized the TRILL protocol, which provides
   transparent Layer 2 forwarding using encapsulation with a hop count
   and IS-IS link state routing. This document specifies the data
   formats and code points for the IS-IS extensions to support TRILL.

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[1](). Introduction

   The IETF has standardized the TRILL protocol, which provides
   transparent Layer 2 forwarding using encapsulation with a hop count
   and [IS-IS] link state routing [RFCtrill]. TRILL provides optimal
   pair-wise forwarding without configuration, safe forwarding even
   during periods of temporary loops, and support for multipathing of
   both unicast and multicast traffic as well as supporting VLANs.
   Intermediate Systems (ISs) implementing TRILL are compatible with
   IEEE 802.1 customer bridges and can incrementally replace such
   bridges.

   This document specifies the data formats and code points for the IS-
   IS [IS-IS] [RFC1195] extensions to support TRILL.

[1.1]() Conventions used in this document

   The terminology and acronyms defined in [RFCtrill] are used herein
   with the same meaning.

   Additional acronyms used in this document:

      IIH - IS-IS Hello

      IS - Intermediate System (for this document, all relevant
      intermediate systems are RBridges)

      NLPID - Network Layer Protocol Identifier

   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. TLV and sub-TLV Extensions to IS-IS for TRILL

This section specifies the data formats and code points for the TLVs
and sub-TLVs added to IS-IS to support the TRILL standard.
Information as to the number of occurrences allowed, such as for a
TLV in a PDU or set of PDUs or for a sub-TLV in a TLV, is provided in
Section 6.

2.1 The Group Address TLV

The Group Address (GADDR) TLV, IS-IS TLV type 142 [TBD], is carried
only in an LSP PDU and carries sub-TLVs that in turn advertise
multicast group listeners. Section 2.1.1 below specifies a sub-TLV
advertising listeners by MAC address. It is anticipated that
additional sub-TLVS for additional address types such as IP addresses
will be specified in other documents. The sub-TLVs under GADDR
constitute a new series of sub-TLV types (see Section 6.2).

GADDR has the following format:

```
+-+-+-+-+-+-+-+-+
|Type=GADDR-TLV |                (1 byte)
+-+-+-+-+-+-+-+-+
|   Length      |                (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      sub-TLVs...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

o Type: TLV Type, set to GADDR-TLV 142 [TBD].

o Length: variable depending on the sub-TLVs carried.

o sub-TLVs: The Group Address TLV value consists of sub-TLVs
   formatted as described in [RFC5305].

2.1.1 The Group MAC Address sub-TLV

The Group MAC Address (GMAC-ADDR) sub-TLV is sub-TLV type number 1
within the GADDR TLV. In TRILL, it is used to advertise multicast
listeners as specified in Section 4.5.5 of [RFCtrill]. It has the
following format:

```
+-+-+-+-+-+-+-+-+
|Type=GMAC-ADDR |                (1 byte)
+-+-+-+-+-+-+-+-+
|   Length      |                (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  RESV |    Topology-ID       | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  RESV |    VLAN-ID           | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Num Group Recs |                (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     GROUP RECORDS (1)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     ................                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     GROUP RECORDS (N)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where each group record is of the form:

```
+-+-+-+-+-+-+-+-+
| Num of Sources|                (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Group Address       (6 bytes)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Source 1 Address    (6 bytes)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Source 2 Address    (6 bytes)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Source M Address    (6 bytes)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

o Type: GADDR sub-TLV Type, set to 1 (GMAC-ADDR).

o Length: Variable, minimum 5.

o RESV: Reserved. 4-bit fields that MUST be sent as zero and ignored
   on receipt.

o Topology-ID: This field is not used in TRILL, where it is sent as
   zero and ignored on receipt, but is included for use by other
   technologies.

o VLAN-ID: This carries the 12-bit VLAN identifier for all
   subsequent MAC addresses in this sub-TLV, or the value zero if no
   VLAN is specified.

o Number of Group Records: A 1-byte integer that is the number of
   group records in this sub-TLV.

o Group Record: Each group record carries the number of sources. It
   then has a 48-bit multicast address followed by 48-bit source MAC
   addresses. If the sources do not fit in a single sub-TLV, the
   same group address may be repeated with different source addresses
   in another sub-TLV of another instance of the Group Address TLV.

2.2 Multi-Topology Aware Port Capability TLV

The Multi Topology aware Port Capability (MT-PORT-CAP) TLV is IS-IS
TLV type 143 [TBD] and has the format shown below. The sub-TLVs that
it carries are a new series of sub-TLVs.

```
+-+-+-+-+-+-+-+-+
|Type=MT PORTCAP|                 (1 bytes)
+-+-+-+-+-+-+-+-+
| Length        |                 (1 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  RESV |    Topology-ID    |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        sub-TLVs...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

o Type: TLV Type, set to MT-PORT-CAP TLV 143 [TBD].

o Length: Variable, minimum 2.

o RESV: 4 reserved bits that MUST be sent as zero and ignored on
   receipt.

o Topology-ID: In TRILL this value is set to zero and ignored on
   receipt. When this TLV is used in other protocols, it may be a
   12-bit field containing the ID of the topology being announced or
   zero if base topology information is being carried.

o sub-TLVs: The TLV value contains sub-TLVs formatted as described
   in [RFC5305].

The MT-PORT-CAP TLV is carried only within a Hello PDU. The sub-
sections of this section below specify sub-TLVs to be carried in the
MT-PORT-CAP TLV.

2.2.1 The Special VLANs and Flags sub-TLV

In TRILL, the Special VLANs and Flags (VLAN-Flags) sub-TLV is carried
in every IIH PDU. It has the following format:

```
   +-+-+-+-+-+-+-+-+
   |Type=VLAN Flags|                  (1 byte)
   +-+-+-+-+-+-+-+-+
   |   Length     |                   (1 byte)
   +--------------+--------------+
   |    Port ID                 |     (2 bytes)
   +-----------------------------+
   |     Sender Nickname        |     (2 bytes)
   +--+--+--+--+-----------------+
   |AF|AC|VM|BY|   Outer.VLAN    |     (2 bytes)
   +--+--+--+--+-----------------+
   |TR|R |R |R |   Desig.VLAN    |     (2 bytes)
   +--+--+--+--+-----------------+
```

o Type: sub-TLV Type, set to MT-PORT-CAP VLAN-Flags sub-TLV 1 [TBD].

o Length: 8.

o Port ID: An ID for the port on which the enclosing TRILL IIH PDU
   is being sent as specified in [RFCtrill] Section 4.4.2.

o Sender nickname: If the sending IS is holding any nicknames as
   discussed in [RFCtrill] Section 3.7, one MUST be included here.
   Otherwise, the field is set to zero. This field is to support
   intelligent end stations that determine the egress IS (RBridge)
   for unicast data through a directory service or the like and need
   a nickname for their first hop to insert as the ingress nickname
   to correctly format a TRILL encapsulated data frame. See
   [RFCtrill] Section 4.6.2 point #8.

o Outer.VLAN: A copy of the 12-bit outer VLAN ID of the TRILL IIH
   frame containing this sub-TLV when that frame was sent, as
   specified in [RFCtrill] Section 4.4.5.

o Desig.VLAN: The 12-bit ID of the designated VLAN for the link as
   specified in [RFCtrill] Section 4.2.4.2.

o AF, AC, VM, BY, and TR: These flag bits have the following meaning
   each, if set to one, as specified in the listed section of
   [RFCtrill]:

```
        RFCtrill
   Bit  Section     Meaning if bit is one
   -------------------------------------

   AF   4.4.2       Originating IS believes it is Appointed Forwarder
                    for the VLAN and port on which the containing IIH
                    PDU was sent.

   AC   4.9.1       Originating port configured as an access port
                    (TRILL traffic disabled).

   VM   4.4.5       VLAN Mapping detected on this link.

   BY   4.4.2       Bypass pseudonode.

   TR   4.9.1       Originating port configured as a trunk port (end
                    station service disabled).
```

   o R: Reserved bit. MUST be sent as zero and ignored on receipt.

2.2.2 Enabled-VLANs sub-TLV

   The optional Enabled-VLANs sub-TLV specifies the VLANs enabled for
   end station service at the port of the originating IS on which the
   Hello was sent as specified in [RFCtrill] Section 4.4.2. It has the
   following format:

```
   +-+-+-+-+-+-+-+-+
   |Type=EnabledVLAN|              (1 byte)
   +-+-+-+-+-+-+-+-+
   |    Length      |              (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |RESV |    Start VLAN ID      | (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | VLAN bit-map....
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   o Type: sub-TLV Type, set to MT-PORT-CAP Enabled-VLANs sub-TLV 2
      [TBD].

   o Length: Variable, minimum 3.

   o RESV: 4 reserved bits that MUST be sent as zero and ignored on
      receipt.

   o Start VLAN ID, VLAN bit-map: The third and subsequent bytes of the
      value provide a bit map of enabled VLANs starting at the VLAN ID

indicated in the lower 12 bits of the first two bytes. The highest

   order bit of the third byte indicates the VLAN equal to the
   starting ID while the lowest order bit of the third byte indicates
   that ID plus 7. Etc.

   If this sub-TLV is present more than once in a Hello PDU, a VLAN is
   enabled for end station service on the port where the Hello was sent
   if this is indicated in any occurrence of this sub-TLV in the Hello.

2.2.3 Appointed Forwarders sub-TLV

   The DRB on a link uses the Appointed Forwarders sub-TLV to inform
   other ISs on the link that they are the designated VLAN-x forwarder
   for one or more ranges of VLAN IDs as specified in Section 4.2.4 of
   [RFCtrill]. It has the following format:

```
   +-+-+-+-+-+-+-+-+
   |Type=ApptFwrdrs|                       (1 byte)
   +-+-+-+-+-+-+-+-+
   |   Length      |                       (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Appointment Information (1)       |  (6 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   ................                  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Appointment Information (N)       |  (6 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   where each appointment is of the form:

```
   +---------------------------+
   |   Appointee Nickname      |  (2 bytes)
   +---------------------------+
   | RESV |    Start.VLAN      |  (2 bytes)
   +---------------------------+
   | RESV |    End.VLAN        |  (2 bytes)
   +---------------------------+
```

   o Type: sub-TLV Type, set to MT-PORT-CAP Appointed Forwarders sub-
      TLV 3 [TBD].

   o Length: 6*n bytes where there are n appointments.

   o Appointee Nickname: The nickname of the IS being appointed a
      forwarder.

   o RESV: 4 bits that MUST be sent as zero and ignored on receipt.

o Start.VLAN, End.VLAN: These fields are the VLAN IDs of the

   appointment range, inclusive. A VLAN's ID appears as both the
   start and end VLAN to specify that single VLAN. As specified in
   Section 4.4 of [RFCtrill], appointing an IS forwarder on a port
   for a VLAN not enabled on that port has no effect.

An IS's nickname may occur as appointed forwarder for multiple VLAN
ranges by occurrences of this sub-TLV within the same or different MT
Port Capability TLVs within an IIH PDU.

2.3 Sub-TLVs for the Router Capability TLV

The Router Capability TLV is specified in [RFC4971]. All of the sub-
sections below of this Section 2.3 specify sub-TLVs that can be
carried in the Router Capability TLV for TRILL.

2.3.1 The TRILL Version sub-TLV

The TRILL Version (TRILL-VER) sub-TLV indicates the maximum version
of the TRILL standard supported. By implication, lower versions are
also supported. If this sub-TLV is missing, the originating IS only
supports the base version of the protocol [RFCtrill].

```
+-+-+-+-+-+-+-+-+
| Type          |                (1 byte)
+-+-+-+-+-+-+-+-+
| Length        |                (1 byte)
+-+-+-+-+-+-+-+-+
| Max-version   |                (1 byte)
+-+-+-+-+-+-+-+-+
```

o Type: Router Capability sub-TLV Type, set to 5 (TRILL-VER).

o Length: 1.

o Max-version: Set to maximum version supported.

2.3.2 The Nickname sub-TLV

The Nickname (NICKNAME) Router Capability sub-TLV carries information
about the nicknames of the originating IS, along with information
about its priority to hold those nicknames as specified in [RFCtrill]
Section 3.7.3. Multiple instances of this sub-TLV may be carried.

```
   +-+-+-+-+-+-+-+-+
   |Type = NICKNAME|                        (1 byte)
   +-+-+-+-+-+-+-+-+
   |   Length      |                        (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                 NICKNAME RECORDS (1)                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                   ...............                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                 NICKNAME RECORDS (N)                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   where each nickname record is of the form:

```
   +-+-+-+-+-+-+-+-+
   | Nickname.Pri  |                (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Tree Root Priority      |  (2 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Nickname           |  (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   o Type: Router Capability sub-TLV Type, set to 6 (NICKNAME).

   o Length: 5*N, where N is the number of nickname records present.

   o Nickname.Pri: An 8-bit unsigned integer priority to hold a
nickname as specified in Section 3.7.3 of [RFCtrill].

   o Tree Root Priority: This is an unsigned 16-bit integer priority to
be a tree root as specified in Section 4.5 of [RFCtrill].

   o Nickname: This is an unsigned 16-bit integer as specified in
Section 3.7 of [RFCtrill].

2.3.3 The Trees sub-TLV

   Each IS providing TRILL service uses the TREES sub-TLV to announce
   three numbers related to the computation of distribution trees as
   specified in Section 4.5 of [RFCtrill]. Its format is as follows:

```
+-+-+-+-+-+-+-+-+
|Type =  TREES  |                  (1 byte)
+-+-+-+-+-+-+-+-+
|  Length       |                  (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Number of trees to compute    | (2 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Maximum trees able to compute | (2 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Number of trees to use        | (2 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

o   Type: Router Capability sub-TLV Type, set to 7 (TREES).

o   Length: 6.

o   Number of trees to compute: An unsigned 16-bit integer as
    specified in Section 4.5 of [RFCtrill].

o   Maximum trees able to compute: An unsigned 16-bit integer as
    specified in Section 4.5 of [RFCtrill].

o   Number of trees to use: An unsigned 16-bit integer as specified in
    Section 4.5 of [RFCtrill].

2.3.4 **The Tree Identifiers Sub-TLV**

   The tree identifiers (TREE-RT-IDs) sub-TLV is an ordered list of
   nicknames. When originated by the IS that has the highest priority
   tree root, it lists the distribution trees that the other ISs are
   required to compute as specified in Section 4.5 of [RFCtrill]. If
   this information is spread across multiple sub-TLVs, the starting
   tree number is used to allow the ordered lists to be correctly
   concatenated. The sub-TLV format is as follows:

```
+-+-+-+-+-+-+-+-+
|Type=TREE-RT-IDs|                 (1 byte)
+-+-+-+-+-+-+-+-+
|   Length      |                  (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Starting Tree Number           | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Nickname (K-th root)        | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Nickname (K+1 - th root)   | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Nickname (...)             |
```

```
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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    o Type: Router Capability sub-TLV Type, set to 8 (TREE-RT-IDs).

    o Length: 2 + 2*n where n is the number of nicknames listed.

    o Starting Tree Number: This identifies the starting tree number of
       the nicknames that are trees for the domain. This is set to 1 for
       the first sub-TLV. Subsequent sub-TLVs will have the starting
       number of the ordered list. In the event a tree identifier can be
       computed from two such sub-TLVs and they are different, then it is
       assumed that this is a transient condition that will get cleared.
       During this transient time, such a tree SHOULD NOT be computed
       unless such computation is indicated by all relevant sub-TLVs
       present.

    o Nickname: The nickname at which a distribution tree is rooted.

2.3.5 The Trees Used Identifiers Sub-TLV

   This Router Capability sub-TLV has the same structure as the Tree
   Identifiers sub-TLV specified in Section 2.3.4. The only difference
   is that its sub-TLV type is set to 9 [TBD] (TREE-USE-IDs) and the
   trees listed are those that the originating IS wishes to use as
   specified in [RFCtrill] Section 4.5.

2.3.6 Interested VLANs and Spanning Tree Roots sub-TLV

   The value of this Router Capability sub-TLV consists of a VLAN range
   and information in common to all of the VLANs in the range for the
   originating IS. This information consists of flags, a variable
   length list of spanning tree root bridge IDs, and an appointed
   forwarder status lost counter, all as specified in the sections of
   [RFCtrill] listed with the respective information items below.

   In the set of LSPs originated by an IS, the union of the VLAN ranges
   in all occurrences of this sub-TLV MUST be precisely the set of VLANs
   for which the originating IS is appointed forwarder on at least one
   port and the VLAN ranges in multiple VLANs sub-TLVs for an IS MUST
   NOT overlap unless the information provided about a VLAN is the same
   in every instance. However, as a transient state these conditions may
   be violated. If a VLAN is not listed in any INT-VLAN sub-TLV for an
   IS, that IS is assumed to be uninterested in receiving traffic for
   that VLAN. If a VLAN appears in more than one INT-VLAN sub-TLV for an
   IS with different information in the different instances, the
   following apply:
       If those sub-TLVs provide different nicknames it is unspecified

which nickname takes precedence,

    The largest appointed forwarder status lost counter is used,
    The originating IS is assumed to be attached to a multicast IPv4
        router for that VLAN if any of the INT-VLAN sub-TLVs assert
        that it is so connected and similarly for IPv6 multicast router
        attachment, and
    The root bridge lists from all of the instances of the VLAN for
        the originating IS are merged.

To minimize such occurrences, wherever possible, an implementation
SHOULD advertise the update to a interested VLAN and spanning tree
roots sub-TLV in the same LSP fragment as the advertisement that it
replaces. Where this is not possible, the two affected LSP fragments
should be flooded as an atomic action. An IS that receives an update
to an existing interested VLAN and spanning tree roots sub-TLV can
minimize the potential disruption associated with the update by
employing a hold-down timer prior to processing the update so as to
allow for the receipt of multiple LSP fragments associated with the
same update prior to beginning processing.

The sub-TLV layout is as follows:

```
+-+-+-+-+-+-+-+-+
|Type = INT-VLAN|                (1 byte)
+-+-+-+-+-+-+-+-+
|   Length      |                (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Nickname                | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+...+-+-+-+-+
|   Interested VLANS                                |  (4 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+...+-+-+-+-+
|   Appointed Forwarder Status Lost Counter        |  (4 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+...+-+-+-+
|       Root Bridges                               |  (6*n bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+...+-+-+-+
```

o Type: Router Capability sub-TLV Type, set to 10 (INT-VLAN).

o Length: 10 + 6*n where n is the number of root bridge IDs.

o Nickname: As specified in [RFCtrill] Section 4.2.4.4, this field
    may be used to associate a nickname held by the originating IS
    with the VLAN range indicated. When not so used, it is set to
    zero.

o Interested VLANS: The Interested VLANs field is formatted as shown
    below.

```
    0    1    2    3    4 - 15       16 - 19     20 - 31
  +----+----+----+----+------------+----------+------------+
  | M4 | M6 |  R |  R | VLAN.start |   RESV   |  VLAN.end  |
  +----+----+----+----+------------+----------+------------+
```

- M4, M6: These bits indicate, respectively, that there is an
  IPv4 or IPv6 multicast router on a link for which the
  originating IS is appointed forwarder for every VLAN in the
  indicated range as specified in [RFCtrill] Section 4.2.4.4 item
  5.1.

- R, RESV: These reserved bits MUST be sent as zero and are
  ignored on receipt.

- VLAN.start and VLAN.end: This VLAN ID range is inclusive. A
  range of one VLAN ID is indicated by setting them both to that
  VLAN ID value.

o Appointed Forwarder Status Lost Counter: This is a count of how
   many times a port that was appointed forwarder for the VLANs in
   the range given has lost the status of being an appointed
   forwarder as discussed in Section 4.8.3 of [RFCtrill]. It is
   initialized to zero at an IS when the LSP sequence number is
   initialized. No special action need be taken at rollover, the
   counter just wraps around.

o Root Bridges: The list of zero or more spanning tree root bridge
   IDs is the set of root bridge IDs seen for all ports for which the
   IS is appointed forwarder for the VLANs in the specified range as
   discussed in [RFCtrill] Section 4.9.3.2. While, of course, only
   one spanning tree root could be seen on any particular port, there
   may be multiple ports in the same VLAN connected to differed
   bridged LANs with different spanning tree roots.

An INT-VLAN sub-TLV asserts that the information provided (multicast
router attachment, appointed forwarder status lost counter, and root
bridges), is the same for all VLANs in the range give. If this is not
the case, the range MUST be split into subranges meeting this
criteria. It is always safe to use sub-TLVs with a "range" of one
VLAN ID but this may be too verbose.

2.3.7 The VLAN Group sub-TLV

The VLAN Group Router Capability sub-TLV consists of two or more VLAN
IDs as specified in [RFCtrill] Section 4.8.4. This sub-TLV indicates
that shared VLAN learning is occurring at the announcing IS between
the listed VLANs. It is structured as follows:

```
   +-+-+-+-+-+-+-+-+
   |Type=VLAN-GROUP|                 (1 byte)
   +-+-+-+-+-+-+-+-+
   |    Length     |                 (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | RESV  |   Primary VLAN ID    |  (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | RESV  |   Secondary VLAN ID    |  (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  more Secondary VLAN IDs ...    (2 bytes each)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   o Type: Router Capability sub-TLV Type, set to 11 (VLAN-GROUP).

   o Length: 4 + 2*n, where n may be 0.

   o RESV: a 4-bit field that MUST be sent as zero and ignored on
      receipt.

   o Primary VLAN-ID: This identifies the primary VLAN-ID.

   o Secondary VLAN-ID: This identifies a secondary VLAN in the VLAN
      Group.

2.4 MTU sub-TLV of the Extended Reachability TLV

   The MTU sub-TLV is used to optionally announce the MTU of a link as
   specified in [RFCtrill] Section 4.2.4.4. It occurs within the
   Extended Reachability TLV (type #22).

```
   +-+-+-+-+-+-+-+-+
   | Type = MTU    |                 (1 byte)
   +-+-+-+-+-+-+-+-+
   |    Length     |                 (1 byte)
   +-+-+-+-+-+-+-+-+
   |F|  Reserved   |                 (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |               MTU             |  (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   o Type: Extended Reachability sub-TLV Type, set to MTU sub-TLV 6
      [TBD].

   o Length: 3.

   o F: Failed. This bit is a one if MTU testing failed on this link at
      the required campus-wide MTU.

   o Reserved: 7 bits that MUST be sent as zero and ignored on receipt.

   o MTU: This field is set to the largest successfully tested MTU size
      for this link, or zero if it has not been tested, as specified in
      Section 4.3.2 of [RFCtrill].

2.5 **TRILL Neighbor TLV**

   The TRILL Neighbor TLV is used in TRILL IIH PDUs (see Section 4.1
   below) in place of the IS Neighbor TLV, as specified in Section
   4.4.2.1 of [RFCtrill]. The structure of the TRILL Neighbor TLV is as
   follows:

```
   +-+-+-+-+-+-+-+-+
   |Type=TRILLNeigh|                 (1 byte)
   +-+-+-+-+-+-+-+-+
   |   Length      |                 (1 byte)
   +-+-+-+-+-+-+-+-+
   |S|L|   RESV     |                 (1 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                  Neighbor RECORDS (1)                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    ................                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                  Neighbor RECORDS (N)                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   The information present for each neighbor is as follows:

```
   +-+-+-+-+-+-+-+-+
   |F|   RESV      |                 (1 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       MTU           |  (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+...+-+-+-+-+-+-+
   |   MAC Address                            | (6 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+...+-+-+-+-+-+-+
```

   o Type: TLV Type, set to TRILL Neighbor TLV 145 [TBD].

   o Length: 1 + 9*n, where n is the number of neighbor records.

   o S: Smallest flag. If this bit is a one, then the list of
      neighbors includes the neighbor with the smallest MAC address.

   o L: Largest flag. If this bit is a one, then the list of neighbors
      includes the neighbor with the largest MAC address.

o RESV: These seven bits are reserved for future use and MUST be set

      to zero on transmission and ignored on receipt.

   o F: failed. This bit is a one if MTU testing to this neighbor
      failed at the required campus-wide MTU (see [RFCtrill] Section
      4.3.1).

   o MTU: This field is set to the largest successfully tested MTU size
      for this neighbor or zero if it has not been tested.

   o MAC Address: The MAC address of the neighbor as in the IS Neighbor
      TLV (#6).

   As specified in [RFCtrill] Section 4.4.2.1, all MAC address may fit
   into one TLV, in which case both the S and L flags would be set to
   one in that TLV. Otherwise, the highest MAC address in a TRILL
   Neighbor TLV with the L flag zero will also appear as a MAC address
   in some other TRILL Neighbor TLV (possibly in a different TRILL IIH
   PDU). And the lowest MAC address in a TRILL Neighbor TLV with the S
   flag zero will also appear in some other TRILL Neighbor TLV (possibly
   in a different TRILL IIH PDU).

3. **The MTU PDUs**

   Two PDUs are added to IS-IS, the MTU-probe and MTU-ack PDUs. They
   are used to optionally determine the MTU on a link between ISs as
   specified in [RFCtrill] Section 4.3.2.

   The MTU PDUs have the IS-IS PDU common header (up through the Maximum
   Area Addresses byte) with two new PDU Type numbers, one each, as
   listed in Section 6. They also have a 20-byte common fixed MTU PDU
   header as shown below.

```
   +------------+
   | PDU Length |                          (2 bytes)
   +------------+-------------------------+
   |    Probe ID                          | (6 bytes)
   +--------------------------------------+
   |    Probe Source ID                   | (6 bytes)
   +--------------------------------------+
   |    Ack Source ID                     | (6 bytes)
   +--------------------------------------+
```

   As with other IS-IS PDUs, the PDU length gives the length of the
   entire IS-IS packet starting with and including the IS-IS common
   header.

   The Probe ID field is an arbitrary 48-bit quantity set by the IS
   issuing an MTU-probe and copied by the responding IS into the
   corresponding MTU-ack. For example, an IS creating an MTU-probe
   could compose this quantity from a port identifier and probe sequence
   number relative to that port.

   The Probe Source ID is set by an IS issuing an MTU-probe to its
   System ID and copied by the responding IS into the corresponding MTU-
   ack.

   The Ack Source ID is set to zero in MTU-probe PDUs. An IS issuing an
   MTU-ack sets this field to its System ID.

   The TLV area follows the MTU PDU header area. This area MAY contain
   an Authentication TLV and MUST be padded to the exact size being
   tested with the Padding TLV. Since the minimum size of the Padding
   TLV is 2 bytes, it would be impossible to pad to exact size if the
   total length of the required information bearing fixed fields and
   TLVs added up to 1 byte less than the desired length; however, the
   length of the fixed fields and substantive TLVs for MTU PDUs will be
   quite small compared with their minimum length (minimum 1470 byte MTU
   on an 802.3 link for example), so this will not be a problem.

4. Use of Existing PDUs and TLVs

The sub-sections below provide details of TRILL use of existing PDUs and TLVs.

4.1 TRILL IIH PDUs

The TRILL IIH PDU is the variation of the LAN IIH PDU used by the TRILL protocol. Section 4.4 of the TRILL standard [RFCtrill] specifies the contents of the TRILL IIH and how its use differs in TRILL from Layer 3 LAN IIH PDU use.

In a TRILL IIH PDU the IS-IS Common Header and the fixed PDU Header are the same as a Level 1 LAN IIH PDU.

The IS-IS Neighbor TLV (#6) is not used in a TRILL IIH and is ignored if it appears there. Instead, TRILL IIH PDUs use the TRILL Neighbor TLV (see Section 2.6).

4.2 Area Address

TRILL uses a fixed zero Area Address as specified in [RFCtrill] Section 4.2.3. This is encoded in a four byte Area Address TLV (TLV #1) as follows:

```
    +-------------------------+-------------------------+
    | 0x01 (Area Address Type) | 0x02 (Length of Value)   |
    +-------------------------+-------------------------+
    | 0x01 (Length of Address) | 0x00 (zero Area Address) |
    +-------------------------+-------------------------+
```

4.3 Protocols Supported

NLPID 0xC0 has been assigned to TRILL [RFCnlpid]. A Protocols Supported TLV (#129, [RFC1195]) including that value SHOULD appear in TRILL IIH PDUs and fragment zero LSP PDUs.

[5](#). **Acknowledgements**

[6](#). **IANA Considerations**

   IANA will allocate the existing registry code points listed in
   [Section 6.1](#) and create the new registries and their initial contents
   as listed in [Section 6.2](#).

[6.1](#) Allocations From Existing Registries

   This document creates two new IS-IS PDUs, namely the MTU-PROBE-PDU,
   and MTU-ACK-PDU, as described in [Section 3](#). IANA will assign a new
   PDU type to these PDUs and reflect them in the PDU registry.
   [suggested values below]

       MTU-PROBE-PDU   Level-1 PDU Number: 23
       MTU-ACK-PDU   Level-1 PDU Number: 28

   This document specifies three new IS-IS TLV types, namely the Group
   Address TLV (GADDR, type 142), the Multi-Topology Aware Port
   Capability TLV (MT-PORT-CAP, type 143), and the TRILL Neighbor TLV
   (type 145), that need to be reflected in the IS-IS TLV code-point
   registry. The PDUs in which these TLVs are permitted for TRILL is
   shown in the table below along with the section of this document
   where they are discussed. The final "NUMBER" column indicates the
   permitted number of occurrences of the TLV in their PDU, or set of
   PDUs in the case of LSP, as follows:
      1+ = MUST occur at least once and MAY occur multiple times. If
             absent, the PDU is ignored.
       * = MAY occur 0, 1, or more times.

	Section	TLV#	IIH	LSP	SNP	NUMBER
GADDR-TLV	2.1	142	-	X	-	*
MT-PORT-CAP-TLV	2.2	143	X	-	-	1+
TRILL Neighbor TLV	2.5	145	X	-	-	*

   This document specifies eight new sub-TLVs from existing sub-TLV
   sequences, namely TRILL Version (TRILL-VER), Nickname, TREES, TREE-
   RT-IDs, TREE-USE-IDs, INT-VLAN, VLAN-GROUP, and MTU. The TLVs in
   which these sub-TLVs occur are shown in the table below along with
   the section of this document where they are discussed. The final
   "NUMBER" column indicates the permitted number of occurrences of the
   sub-TLV cumulatively within all occurrences of their TLV in that
   TLV's carrying PDU (or set of PDUs in the case of LSP), as follows:
      0-1 = MAY occur zero or one times. If it occurs more than once,
             results are unspecified.
       * = MAY occur 0, 1, or more times.

	Section	sub-TLV#	Router Capability	Extended IS Reach	NUMBER
TRILL-VER	2.3.1	5	X	-	0-1
NICKNAME	2.3.2	6	X	-	*
TREES	2.3.3	7	X	-	0-1
TREE-RT-IDs	2.3.4	8	X	-	*
TREE-USE-IDs	2.3.5	9	X	-	*
INT-VLAN	2.3.6	10	X	-	*
VLAN-GROUP	2.3.7	11	X	-	*
MTU	2.4	6	-	X	0-1

6.2 New Sub-Registries Created and Their Initial Contents

This document creates new sub-TLV IS-IS sub-registries for sub-TLVs
within the Group Address (GADDR) and Multi-topology Port Capability
(MT-PORT-CAP) TLVs and specifies four sub-TLVs within these two new
registries, namely Group MAC Address (GMAC-ADDR), VLAN and Flags,
Enabled-VLANs, and AppointedForwarders. The TLVs in which these sub-
TLVs occur are shown in the table below along with the section of
this document where they are discussed. The final "NUMBER" column
indicates the permitted number of occurrences of the sub-TLV
cumulatively within all the occurrences of their TLV in that TLV's
carrying PDU (or set of PDUs in the case of LSP) as follows:

    1 = MUST occur exactly once. If absent, the PDU is ignored. If
         it occurs more than once, results are unspecified.
    * = MAY occur 0, 1, or more times.

	Section	sub-TLV#	Group Address	MT Port Capability	NUMBER
GMAC-ADDR	2.1.1	1	X	-	*
VLAN-FLAGS	2.2.1	1	-	X	1
Enabled-VLANs	2.2.2	2	-	X	*
AppointedFwrdrs	2.2.3	3	-	X	*

The assignment of additional sub-TLV type values in the Group Address
and MT Port Capability TLVs requires IETF Review as specified in
[RFC5226] except that types values 0x00 and 0xFF require an IETF
Standards action for assignment.

7. Security Considerations

For general TRILL protocol security considerations, see [RFCtrill].

This document raises no new security issues for IS-IS. IS-IS security
may be used to secure the IS-IS messages discussed here. See
[RFC5304] and [RFC5310].

8. References

   Normative and informative references for this document are given
   below.

8.1 Normative References

   [IS-IS] - ISO/IEC 10589:2002, Second Edition, "Intermediate System to
         Intermediate System Intra-Domain Routing Exchange Protocol for
         use in Conjunction with the Protocol for Providing the
         Connectionless-mode Network Service (ISO 8473)", 2002.

   [RFC1195] - Callon, R., "Use of OSI IS-IS for Routing in TCP/IP and
         Dual Environments", 1990.

   [RFC2119] - Bradner, S., "Key words for use in RFCs to Indicate
         Requirement Levels", BCP 14, RFC 2119, March 1997.

   [RFC4971] - Vasseur, JP. and N. Shen, "Intermediate System to
         Intermediate System (IS-IS) Extensions for Advertising Router
         Information", 2007.

   [RFC5226] - Narten, T. and H. Alvestrand, "Guidelines for Writing an
         IANA Considerations Section in RFCs", BCP 26, RFC 5226, May
         2008.

   [RFC5305] - Li, T. and H. Smit, "IS-IS Extensions for Traffic
         Engineering", 2008.

   [RFCtrill] - Perlman, R., D. Eastlake, D. Dutt, S. Gai, and A.
         Ghanwani, "RBridges: Base Protocol Specification", draft-ietf-
         trill-rbridge-protocol-16.txt, in RFC Editor's queue.

   [RFCnlpid] - Eastlake, D., "IANA Considerations for Network Layer
         Protocol Identifiers", draft-eastlake-nlpid-iana-
         considerations-04.txt, in RFC Editor's queue.

8.2 Informative References

   [RFC5304] - Li, T. and R. Atkinson, "IS-IS Cryptographic
         Authentication", RFC 5304, October 2008.

   [RFC5310] - Bhatia, M., Manral, V., Li, T., Atkinson, R., White, R.,
         and M. Fanto, "IS-IS Generic Cryptographic Authentication", RFC
         5310, February 2009.

Change History

    RFC Editor Note: Delete this section before publication.

Changes from -00 to -01

    Numerous clarification and editorial changes based mostly on
    excellent comments provided by Mike Shand.

    Addition of [Section 4.3](#) on Protocols Supported TLV.

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