TRILL: Interface Addresses APPsub-TLV
<draft-ietf-trill-ia-appsubtlv-02.txt>

Abstract
   This document specifies a TRILL (Transparent Interconnection of Lots
   of Links) IS-IS application sub-TLV that enables the reporting by a
   TRILL switch of sets of addresses such that all of the addresses in
   each set designate the same interface (port) and the reporting for
   such a set of the TRILL switch by which it is reachable. For example,
   a 48-bit MAC (Media Access Control) address, IPv4 address, and IPv6
   address can be reported as all corresponding to the same interface
   reachable by a particular TRILL switch. Such information could be
   used in some cases to synthesize responses to or by-pass the need for
   the Address Resolution Protocol (ARP), the IPv6 Neighbor Discovery
   (ND) protocol, or the flooding of unknown MAC addresses.

Status of This Memo

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1. Introduction

   This document specifies a TRILL (Transparent Interconnection of Lots
   of Links) [RFC6325] IS-IS application sub-TLV (APPsub-TLV [RFC6823])
   that enables the convenient representation of sets of addresses such
   that all of the addresses in each set designate the same interface
   (port). For example, a 48-bit MAC (Media Access Control [RFC7042])
   address, IPv4 address, and IPv6 address can be reported as all three
   designating the same interface. In addition, a Data Label (VLAN or
   Fine Grained Label (FGL [RFC7172])) is specified for the interface
   along with the TRILL switch, and optionally the TRILL switch port,
   from which the interface is reachable. Such information could be
   used in some cases to synthesize responses to or by-pass the need for
   the Address Resolution Protocol (ARP [RFC826]), the IPv6 Neighbor
   Discovery (ND [RFC4861]) protocol, the Reverse Address Resolution
   Protocol (RARP [RFC903]), or the flooding of unknown destination MAC
   addresses [RFC7042]. If the information report is complete, it can
   also be used to detect and discard packets with forged source
   addresses.

   This APPsub-TLV appears inside the TRILL GENINFO TLV specified in
   ESADI [RFC7357] but may also occur in other application contexts.
   Directory Assisted TRILL Edge services [DirectoryScheme] are expected
   to make use of this APPsub-TLV.

   Although, in some IETF protocols, address field types are represented
   by Ethertype [RFC7042] or Hardware Type [RFC5494], only Address
   Family Number (AFN) is used in this APPsub-TLV to represent address
   field type.

1.1 Conventions Used in This Document

   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]. Capitalized
   IANA Considertions terms such as "Expert Review" are to be
   interpreted as described in [RFC5226].

   The terminology and acronyms of [RFC6325] are used herein along with
   the following additional acronyms and terms:

   AFN: Address Family Number

   APPsub-TLV: Application sub-TLV [RFC6823]

   Data Label: VLAN or FGL

   FGL: Fine Grained Label [RFC7172]

    IA: Interface Addresses

    RBridge: An alternative name for a TRILL switch

    TRILL switch: A device that implements the TRILL protocol

2. Format of the Interface Addresses APPsub-TLV

   The Interface Addresses (IA) APPsub-TLV is used to advertise that a
   set of addresses indicate the same interface (port) within a Data
   Label (VLAN or FGL) and to associate that interface with the TRILL
   switch, and optionally the TRILL switch port, by which the interface
   is reachable. These addresses can be in different address families.
   For example, it can be used to declare that a particular interface
   with specified IPv4, IPv6, and 48-bit MAC addresses in some
   particular Data Label is reachable from a particular TRILL switch.

   The Template field in a particular Interface Addresses APPsub-TLV
   indicates the format of each Address Set it carries. Certain well-
   known sets of addresses are represented by special values. Other sets
   of addresses are specified by a list of AFNs. The Template format
   that uses a list of AFNs provides an explicit pattern for the type
   and order of addresses in each Address Set in the IA APPsub-TLV that
   includes that Template.

   A device or application making use of IA APPsub-TLV data is not
   required to make use of all IA data. For example, a device or
   application that was only interested in MAC and IPv6 addresses could
   ignore any IPv4 or other types of address information that was
   present.

   The figure below shows an IA APPsub-TLV as it would appear inside an
   IS-IS FS-LSP using an extended flooding scope [RFC7356] TLV, for
   example in ESADI [RFC7357]. Within an IS-IS PDU using traditional
   [ISO-10589] TLVs, the Type and Length would be one byte unsigned
   integers equal to or less than 255.

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Type = TBD1                   |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Length                        |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Addr Sets End                 |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Nickname                      |  (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Flags         |                  (1 byte)
+-+-+-+-+-+-+-+-+
| Confidence    |                  (1 byte)
+-+-+-+-+-+-+-+-+-
| Template ...                     (variable)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...-+
| Address Set 1    (size determined by Template)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...-+
| Address Set 2    (size determined by Template)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...-+
|    ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...-+
| Address Set N    (size determined by Template)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-...-+
| optional sub-sub-TLVs ...
+-+-+-+-+-+-+-+-+-+-+-...
```

                  Figure 1. The Interface Addresses APPsub-TLV

   o   Type: Interface Addresses TRILL APPsub-TLV type, set to TBD1 (IA-
       SUBTLV).

   o   Length: Variable, minimum 7. If length is 6 or less or if the
       APPsub-TLV extends beyond the size of an encompassing TRILL
       GENINFO TLV or other context, the APPsub-TLV MUST be ignored.

   o   Addr Sets End: The unsigned integer offset of the byte, within the
       IA APPsub-TLV value part, of the last byte of the last Address
       Set. This will be the byte just before the first sub-sub-TLV if
       any sub-sub-TLVs are present (see Section 3). If this is equal to
       Length, there are no sub-sub-TLVs. If this is greater than Length
       or points to before the end of the Template, the IA APPsub-TLV is
       corrupt and MUST be discarded. This field is always two bytes in
       size.

   o   Nickname: The nickname of the TRILL switch by which the address
       sets are reachable. If zero, the address sets are reachable from
       the TRILL switch originating the message containing the APPsub-TLV
       (for example, an ESADI [RFC7357] message).

   o   Flags: A byte of flags as follows:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|D|L|N|  RESV   |
+-+-+-+-+-+-+-+-+
```

D: Directory flag: If D is one, the APPsub-TLV contains
   Directory information [RFC7067].

L: Local flag: If L is one, the APPsub-TLV contains information
   learned locally by observing ingressed frames [RFC6325].
   (Both D and L can be one in the same IA APPsub-TLV if a
   TRILL switch that had learned an address locally and also
   advertised it as a directory.)

N: Notify flag: When a TRILL switch receives a new IA APPsub-
   TLV (one in a ESADI-LSP fragment with a higher sequence
   number or a new message of some other type) and the N bit is
   one, the TRILL switch then checks the contents of the
   APPsub-TLV for address sets including both an IP address and
   a MAC address. For each such address set it finds, a
   gratuitous ARP [RFC826] or spontaneous Neighbor
   Advertisement [RFC4861], depending on whether the IP address
   is IPv4 or IPv6 respectively, may be sent. In both cases,
   these are sent out all the ports of the TRILL switch
   offering end station service and are in the VLAN or FGL of
   the address set information, that is, are Appointed
   Forwarder for the VLAN or for the VLAN to which the FGL
   maps.

RESV: Additional reserved flag bits that MUST be sent as zero
   and ignored on receipt.

o Confidence: This 8-bit unsigned quantity in the range 0 to 254
   indicates the confidence level in the addresses being transported
   [RFC6325]. A value of 255 is treated as if it was 254.

o Template: The initial byte of this field is the unsigned integer
   K. If K has a value from 1 to 31, it indicates that this initial
   byte is followed by a list of K AFNs (Address Family Numbers) that
   specify the exact structure and order of each Address Set
   occurring later in the APPsub-TLV. K can be 1, which is the
   minimum valid value. If K is zero, the IA APPsub-TLV is ignored.
   If K is 32 to 254, the length of the Template field is one byte
   and its value is intended to correspond to a particular ordered
   set of AFNs some of which are specified below. If K is 255, the
   length of the Template filed is three bytes and the values of the
   second and third byte, considered as an unsigned integer in
   network byte order, are reserved to correspond to future specified
   ordered sets of AFNs.

If the Template uses explicit AFNs, it looks like the following, with the number of AFNs up to 31 equal to K.

```
+-+-+-+-+-+-+-+-+
| K             |                    (1 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| AFN 1                         |    (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| AFN 2                         |    (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| AFN K                         |    (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

For K in the 32 to 102 range, values indicate combinations of a specific number of MAC addresses, IPv4 addresses, IPv6 addresses, and TRILL switch port IDs appearing in that order. The value of K is

$$K = 31 + M + 3*v4 + 9*v6 + 36*P$$

where M is 0, 1, or 2 (0 if no MAC address is present, 1 if a 48-bit MAC is present, 2 if a MAC/24 (see Section 5.1) is present), v4 is the number of IPv4 addresses (limited to 0, 1, or 2) and v6 is the number of IPv6 addresses (limited to 0 through 3 inclusive), and P is the number of TRILL switch port IDs (limited to 0 or 1); however, the number of MAC, IPv4, and IPv6 addresses and TRILL switch ports cannot all be simultaneously zero. That equation specifies values of K from 32 through 102, the value 31 not being permitted but instead representing an explicit Template with 31 AFNs. Values from 103 through 254 of the byte value are available for assignment by Expert Review (see Section 5). K = 255 indicates a three-byte Template field as specified above. All values (0 through 65,545) of this two-byte value are available for assignment by Expert Review.

If an unknown Template K value in the range 103 to 254 is received or a K of 255 followed by an unknown two byte value, the IA APPsub-TLV MUST be ignored.

o AFN: A two-byte Address Family Number. The number of AFNs present is given by K except that there are no AFNs if K is greater than 31. The AFN sequence specifies the structure of the Address Sets occurring later in the TLV. For example, if Template Size is 2 and the two AFNs present are the AFNs for a 48-bit MAC and an IPv4 address, in that order, then each Address set present will consist of a 6-byte MAC address followed by a 4-byte IPv4 address. If any AFNs are present that are unknown to the receiving IS and the length of the corresponding address is not provided by a sub-sub-

TLV as specified below, the receiving IS will be unable to parse
the Address Sets and MUST ignore the IA APPsub-TLV.

o Address Set: Each address set in the APPsub-TLV consists of
   exactly the same sequence of addresses of the types specified by
   the Template earlier in the APPsub-TLV. No alignment, other than
   to a byte boundary, is guaranteed. The addresses in each Address
   Set are contiguous with no unused bytes between them and the
   Address Sets are contiguous with no unused bytes between
   successive Address Sets. The Address Sets must fit within the TLV.

o sub-sub-TLVs: If the Address Sets indicated by Addr Sets End do
   not completely fill the Length of the APPsub-TLV, the remaining
   bytes are parsed as sub-sub-TLVs [RFC5305]. Any such sub-sub-TLVs
   that are not known to the receiving TRILL switch are ignored.
   Should this parsing not be possible, for example there is only one
   remaining byte or an apparent sub-sub-TLV extends beyond the end
   of the TLV, the containing IA APPsub-TLV is considered corrupt and
   is ignored. (Several sub-sub-TLV types are specified in Section
   3.)

Different IA APPsub-TLVs within the same or different LSPs or other
data structures may have different Templates. The same AFN may occur
more than once in a Template and the same address may occur in
different address sets. For example, a 48-bit MAC address interface
might have three different IPv6 addresses. This could be represented
by an IA APPsub-TLV whose Template specifically provided for one
EUI-48 address and three IPv6 addresses, which might be an efficient
format if there were multiple interfaces with that pattern.
Alternatively, a Template with one 48-bit MAC and one IPv6 address
could be used in an IA APPsub-TLV with three address sets each having
the same MAC address but different IPv6 addresses, which might be the
most efficient format if only one interface had multiple IPv6
addresses and other interfaces had only one IPv6 address.

In order to be able to parse the Address Sets, a receiving TRILL
switch must know at least the size of the address for each AFN or
address type the Template specifies; however, the presence of the
Addr Set End field means that the sub-sub-TLVs, if any, can always be
located by a receiver. A TRILL switch can be assumed to know the
size of the AFNs mentioned in Section 5. Should a TRILL switch wish
to include an AFN that some receiving TRILL switch in the campus may
not know, it SHOULD include an AFN-Size sub-sub-TLV as described in
Section 3.1. If an IA APPsub-TLV is received with one or more AFNs in
its template for which the receiving TRILL switch does not know the
length and for which an AFN-Size sub-sub-TLV is not present, that IA
APPsub-TLV MUST be ignored.

3. IA APPsub-TLV sub-sub-TLVs

   IA APPsub-TLVs can have trailing sub-sub-TLVs [RFC5305] as specified
   below. These sub-sub-TLVs occur after the Address Sets and the
   amount of space available for sub-sub-TLVs is determined from the
   overall IA APPsub-TLV length and the value of the Addr Set End byte.

   There is no ordering restriction on sub-sub-TLVs. Unless otherwise
   specified each sub-sub-TLV type can occur zero, one, or many times in
   an IA APPsub-TLV. Any sub-sub-TLVs for which the Type is unknown are
   ignored.

   The sub-sub-TLVs data structures shown below, with two byte Types and
   Lengths, assume that the enclosing IA-APPsubTLV is in an extended LSP
   TLV [RFC7356] or some non-LSP context. If they were used in a IA-
   APPsubTLV in a traditional LSP [ISO-10589], the only one byte Types
   and Lengths could be used. As a result, any sub-sub-TLV types greater
   than 255 could not be used and Length would be limited to 255.

3.1 AFN Size sub-sub-TLV

   Using this sub-sub-TLV, the originating TRILL switch can specify the
   size of an address type. This is useful under two circumstances as
   follows:

   1. One or more AFNs that are unknown to the receiving TRILL switch
      appears in the template. If an AFN Size sub-sub-TLV is present for
      each such AFN, then at least the IA APPsub-TLV can be parsed and
      possibly other addresses in each address set can still be used.

   2. If an AFN occurs in the Template that represents a variable length
      address, this sub-sub-TLV gives its size for all occurrences in
      that IA APPsub-TLV.

```
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        | Type = AFNsz                  |  (2 byte)
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        | Length                        |  (2 byte)
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        | AFN Size Record 1                           |  (3 bytes)
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        | AFN Size Record 2                           |  (3 bytes)
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        | ...                                         |
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        | AFN Size Record N                           |  (3 bytes)
        +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where each AFN Size Record is structured as follows:

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   AFN                         | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  AdrSize     |                  (1 byte)
+-+-+-+-+-+-+-+
```

o Type: AFN-Size sub-sub-TLV type, set to 1 (AFNsz).

o Length: 3*n where n is the number of AFN Size Records present. If
   Length is not a multiple of 3, the sub-sub-TLV MUST be ignored.

o AFN Size Record(s): Zero or more 3-byte records, each giving the
   size of an address type identified by an AFN,

o AFN: The AFN whose length is being specified by the AFN Size
   Record.

o AdrSize: The length in bytes of addresses specified by the AFN
   field as an unsigned integer.

An AFN Size sub-sub-TLV for any AFN known to the receiving TRILL
switch is compared with the size known to the TRILL switch. If they
differ the IA APPsub-TLV is assumed to be corrupt and MUST be
ignored.

3.2 Fixed Address sub-sub-TLV

There may be cases where, in a particular Interface Addresses APP-
subTLV, the same address would appear in every address set across the
APP-subTLV. To avoid wasted space, this sub-sub-TLV can be used to
indicate such a fixed address. The address or addresses incorporated
into the sets by this sub-sub-TLV are NOT mentioned in the IA APPsub-
TLV Template.

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Type=FIXEDADR                 | (2 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Length                        | (2 byte)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| AFN                           | (2 bytes)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Fixed Address                   (variable)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-...
```

o Type: Data Label sub-sub-TLV type, set to 2 (FIXEDADR).

   o Length: variable, minimum 2. If Length is 0 or 1 or less, the sub-
      sub-TLV MUST be ignored.

   o AFN: Address Family Number of the Fixed Address.

   o Fixed Address: The address of the type indicated by the preceding
      AFN field that is considered to be part of every Address Set in
      the IA APPsub-TLV.

   The Length field implies a size for the Fixed Address. If that size
   differs from the size of the address type for the given AFN as known
   by the receiving TRILL switch, the Fixed Address sub-sub-TLV is
   considered corrupt and MUST be ignored.

3.3 Data Label sub-sub-TLV

   This sub-sub-TLV indicates the Data Label within which the interfaces
   listed in the IA APPsub-TLV are reachable. It is useful if the IA
   APPsub-TLV occurs outside of the context of a message specifying the
   Data Label or if it is desired and permitted to override that
   specification. Multiple occurrences of this sub-sub-TLV indicate
   that the interfaces are reachable in all of the Data Labels given.

```
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |Type=DATALEN                   | (2 byte)
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      | Length                        | (2 byte)
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      | Data Label                      (variable)
      +-+-+-+-+-+-+-+-+-+-+-+-+-...
```

   o Type: Data Label sub-TLV type, set to 3 (LABEL).

   o Length: 2 or 3. If Length is some other value, the sub-sub-TLV
      MUST be ignored.

   o Data Label: If length is 2, the bottom 12 bits of the Data
      Label are a VLAN ID and the top 4 bits are reserved (MUST be
      sent as zero and ignored on receipt). If the length is 3, the
      three Data Label bytes contain an FGL [RFC7172].

3.4 Topology sub-sub-TLV

   The presence of this sub-sub-TLV indicates that the interfaces given
   in the IA APPsub-TLV are reachable in the topology give. It is useful
   if the IA APPsub-TLV occurs outside of the context of a message

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indicating the topology or if it is desired and permitted to override
that specification. If it occurs multiple times, then the Address
Sets are in all of the topologies given.

```
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Type=DATALEN                   |  (2 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Length                        |  (2 byte)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | RESV  |         Topology      |  (2 bytes)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   o Type: Topology sub-TLV type, set to 4 (TOPOLOGY).

   o Length: 2. If Length is some other values, the sub-sub-TLV MUST
      be ignored.

   RESV: Four reserved bits. MUST be sent as zero and ignored on
      receipt.

   o Topology: The 12-bit topology number [RFC5120].

4. Security Considerations

   The integrity of address mapping and reachability information and the
   correctness of Data Labels (VLANs or FGLs [RFC7172]) are very
   important. Forged, altered, or incorrect address mapping or Data
   Labeling can lead to delivery of packets to the incorrect party,
   violating security policy. However, this document merely describes a
   data format and does not provide any explicit mechanisms for securing
   that information, other than a few trivial consistency checks that
   might detect some corrupted data. Security on the wire, or in
   storage, for this data is to be providing by the transport or storage
   used. For example, when transported with ESADI [RFC7357] or RBridge
   Channel [RFC7178], ESADI security or Channel Tunnel [ChannelTunnel]
   security mechanisms can be used, respectively.

   The address mapping and reachability information, if known to be
   complete and correct, can be used to detect some cases of forged
   packet source addresses [RFC7067]. In particular, if native traffic
   from an end station is received by a TRILL switch that would
   otherwise accept it but authoritative data indicates the source
   address should not be reachable from the receiving TRILL switch, that
   traffic should be discarded. The data format specified in this
   document may optionally include TRILL switch Port ID number so that
   this forged address filtering can be optionally applied with port
   granularity.

   See [RFC6325] for general TRILL Security Considerations.

5. IANA Considerations

    The following subsections specify IANA actions.

5.1 AFN Number Allocation

    IANA has allocated the following AFN values that may be particularly
    useful for IA APPSub-TLVs:

          Hex   Decimal   Description   References
          -----   -------   -----------   ----------

          0001   1   IPv4
          0002   2   IPv6
          4005   16389   48-bit MAC   [RFC7042]
          4006   16390   64-bit MAC   [RFC7042]
          4007   16391   OUI   This document.
          4008   16392   MAC/24   This document.
          4009   16393   MAC/40   This document.
          400A   16394   IPv6/64   This document.
          400B   16395   RBridge Port ID This document.

    Other AFNs can be found at http://www.iana.org/assignments/address-
    family-numbers

    The OUI AFN is provided so that MAC addresses can be abbreviated if
    they have the same upper 24 bits. A MAC/24 is a 24-bit suffix
    intended to be pre-fixed by an OUI to create a 48-bit MAC address
    [RFC7042]; in the absence of an OUI, a MAC/24 entry cannot be used.
    A MAC/40 is a suffix intended to be pre-fixed by an OUI to create a
    64-bit MAC address [RFC7042]; in the absence of an OUI, a MAC/40
    entry cannot be used.

    Typically, an OUI would be provided as a Fixed Address sub-sub-TLV
    (see Section 3.2).

    After Fixed Address sub-sub-TLV processing above, each address set is
    processed by combining each OUI in the address set with each MAC/24
    and each MAC/40 address in the address set. Depending on how many of
    each of these address types is present, zero or more 48-bit and/or
    64-bit MAC addresses may be produced that are considered to be part
    of the address set. If there are no MAC/24 or MAC/40 addresses
    present, any OUI's are ignored. If there are no OUIs, any MAC/24
    and/or MAC/40s are ignored. If there are K1 OUIs, K2 MAC/24s, and K3
    MAC/40s, K1*K2 48-bit MACs are synthesized and K1*K3 64-bit MACs are
    synthesized.

    IPv6/64 is an 8-byte quantity that is the first 64 bits of an IPv6

address. IPv6/64s are ignored unless, after the processing above in
this sub-section, there are one or more 48-bit and/or 64-bit MAC
addresses in the address set to provide the lower 64 bits of the IPv6
address. For this purpose, an 48-bit MAC address is expanded to 64
bits as described in [RFC7042]. If there are K4 IPv6/64s present and
K5 48- and 64-bit MAC addresses present, K4*K5 128-bit IPv6 addresses
are synthesized.

5.2 IA APPsub-TLV Sub-Sub-TLVs SubRegistry

   IANA is requested to establish a new subregistry of the TRILL
   Parameter Registry for sub-sub-TLVs of the Interface Addresses
   APPsub-TLV with initial contents as shown below.

      Name: Interface Addresses APPsub-TLV Sub-Sub-TLVs

      Procedure: Expert Review

      Note: Types greater than 255 are not usable in some contexts.

      Reference: This document

         Type   Description   Reference
         ------   -----------   ---------
            0   Reserved
            1   AFN Size   This document
            2   Fixed Address   This document
            3   Data Label   This document
            4   Topology   This document
         5-254   Available
          255   Reserved
       256-65534   Available
        65535   Reserved

5.3 IA APPsub-TLV Number

   IANA has allocated TBD1 as the Type for the IA APPsub-TLV in the
   "TRILL APPsub-TLV Types under IS-IS TLV 251 Application Identifier 1"
   registry from the range under 256. In the registry the Name is "IA"
   and the Reference is this document.

Acknowledgments

Appendix A: Examples

   Below are example IA APPsub-TLVs.

A.1 Simple Example

   Below is an annotated IA APPsub-TLV carrying two simple pairs of
   EUI-48 MAC addresses and IPv4 addresses from a Push Directory
   [RFC7042]. No sub-sub-TLVs are included.

```
   0x0002(TBD)     Type: Interface Addresses
   0x001B          Length: 27 (=0x1B)
   0x001B          Address Sets End: 27 (=0x1B)
   0x1234          RBridge Nickname from which reachable
   0b10000000      Flags: Push Directory data
   0xE3            Confidence = 227
   35              Template: 35 (0x23) = 31 + 1(MAC48) + 3*1(IPv4)

           Address Set One
   0x00005E0053A9   48-bitMAC address
   198.51.100.23    IPv4 address

           Address Set Two
   0x00005E00536B   48-bit MAC address
   203.0.113.201    IPv4 address
```

   Size includes 7 for the fixed fields though and including the one
   byte template, plus 2 times the Address Set size. Each Address Set is
   10 bytes, 6 for the 48-bit MAC address plus 4 for the IPv4 address.
   So total size is 7 + 2*10 = 27.

   See Section 2 for more information on Template.

A.2 Complex Example

   Below is an annotated IA APPsub-TLV carrying three sets of addresses,
   each consisting of an EUI-48 MAC address, an IPv4 addresses, an IPv6
   address, and an RBridge Port ID, all from a Push Directory [RFC7042].
   The IPv6 address for each address set is synthesized from the MAC
   address given in that set and the IPv6/64 64-bit prefix provided
   through a Fixed Address sub-sub-TLV. In addition, a sub-sub-TLV is
   included that provides an FGL which overrides whatever Data Label may
   be provided by the envelope (for example an ESADI-LSP [RFC7357])
   within which this IA APPsub-TLV occurs.

```
0x0002(TBD)     Type: Interface Addresses
0x0036          Length: 54 (=0x36)
0x0021          Address Sets End: 33 (=0x21)
0x4321          RBridge Nickname from which reachable
0b10000000      Flags: Push Directory data
0xD3            Confidence = 211
72              Template: 72(0x48)=31+1(MAC48)+3*1(IPv4)+36*1(P)

        Address Set One
0x00005E0053DE   48-bitMAC address
198.51.100.105   IPv4 address
0x1DE3           RBridge Port ID

        Address Set Two
0x00005E0053E3   48-bit MAC address
203.0.113.89     IPv4 address
0x1DEE           RBridge Port ID

        Address Set Three
0x00005E0053D3   48-bit MAC address
192.0.2.139      IPv4 address
0x01DE           RBridge Port ID

        sub-sub-TLV One
0x0003           Type: Data Label
0x0003           Length: implies FGL
0xD3E3E3         Fine Grained Label

        sub-sub-TLV Two
0x0002           Type: Fixed Address
0x000A           Size: 0x0A = 10
0x400A           AFN: IPv6/64
0x20010DB800000000   IPv6 Prefix: 2001:DB8::
```

See Section 2 for more information on Template.

The Fixed Address sub-sub-TLV causes the IPv6/64 value give to be
treated as if it occurred as a 4th entry inside each of the three
Address Sets. When there is an IPv6/64 entry and a 48-bit MAC entry,
the MAC value is expanded by inserting 0xFFFE immediately after the
OUI and the resulting 64-bit value is used as the lower 64 bits of
the resulting IPv6 address [RFC7042]. As a result, a receiving TRILL
switch would treat the three Address Sets shown as if they had an
IPv6 address in them as follows:

```
        Address Set One
   0x20010DB80000000000005EFFFE0053DE  IPv6 Address

        Address Set Two
   0x20010DB80000000000005EFFFE0053E3  IPv6 Address

        Address Set Three
   0x20010DB80000000000005EFFFE0053D3  IPv6 Address
```

As an alternative to the compact "well know value" Template encoding used in this example above, the less compact explicit AFN encoding could have been used. In that case, the IA APPsub-TLV would have started as follows:

```
   0x0002(TBD)   Type: Interface Addresses
   0x003C        Length: 60 (=0x3C)
   0x0027        Address Sets End: 39 (=0x27)
   0x4321        RBridge Nickname from which reachable
   0b10000000    Flags: Push Directory data
   0xD3          Confidence = 211
   0x3           Template: 3 AFNs
   0x4005        AFN: 48-bit MAC
   0x0001        AFN: IPv4
   0x400B        AFN: RBridge Port ID
```

As a final point, since the 48-bit MAC addresses in these three Address Sets all have the same OUI (the IANA OUI [RFC7042]), it would have been possible to just have a MAC/24 value giving the lower 24 bits of the MAC in each Address Set. The OUI would them be supplied by a second Fixed Address sub-sub-TLV proving the OUI. With N Address Sets, this would have saved 3*N or 9 bytes in this case at the cost of 9 bytes (2 each for the type and length of the sub-sub-TLV, 2 for the OUI AFN number, and 3 for the OUI). So, with just three Address Sets, there would be no net saving; however, with a larger number of Address Sets, there would be a net savings.

Appendix Z: Change History

From -00 to -01

    1. Update references for RFC publications.

    2. Add this Change History Appendix.

From -01 to -02

    1. Fix off-by-one errors in body text and examples for well known
       Template values.

    2. Update for drafts published as RFCs and change in Author Address.

    3. Minor editorial improvements.

Normative References

    [ISO-10589] - 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.

    [RFC826] - Plummer, D., "An Ethernet Address Resolution Protocol",
          RFC 826, November 1982.

    [RFC903] - Finlayson, R., Mann, T., Mogul, J., and M. Theimer, "A
          Reverse Address Resolution Protocol", STD 38, RFC 903, June
          1984.

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

    [RFC4861] - Narten, T., Nordmark, E., Simpson, W., and H. Soliman,
          "Neighbor Discovery for IP version 6 (IPv6)", RFC 4861,
          September 2007.

    [RFC5120] - Przygienda, T., Shen, N., and N. Sheth, "M-ISIS: Multi
          Topology (MT) Routing in Intermediate System to Intermediate
          Systems (IS-ISs)", RFC 5120, February 2008.

    [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", RFC 5305, October 2008.

    [RFC6325] - Perlman, R., Eastlake 3rd, D., Dutt, D., Gai, S., and A.
          Ghanwani, "Routing Bridges (RBridges): Base Protocol
          Specification", RFC 6325, July 2011.

    [RFC6823] - Ginsberg, L., Previdi, S., and M. Shand, "Advertising
          Generic Information in IS-IS", RFC 6823, December 2012.

    [RFC7042] - Eastlake 3rd, D. and J. Abley, "IANA Considerations and
          IETF Protocol and Documentation Usage for IEEE 802 Parameters",
          BCP 141, RFC 7042, October 2013.

    [RFC7172] - Eastlake 3rd, D., Zhang, M., Agarwal, P., Perlman, R.,
          and D. Dutt, "Transparent Interconnection of Lots of Links
          (TRILL): Fine-Grained Labeling", RFC 7172, May 2014.

    [RFC7356] - Ginsberg, L., Previdi, S., and Y. Yang, "IS-IS Flooding
          Scope Link State PDUs (LSPs)", RFC 7356, September 2014,
          <http://www.rfc-editor.org/info/rfc7356>.

     [RFC7357] - Zhai, H., Hu, F., Perlman, R., Eastlake 3rd, D., and O.
          Stokes, "Transparent Interconnection of Lots of Links (TRILL):
          End Station Address Distribution Information (ESADI) Protocol",
          RFC 7357, September 2014, <http://www.rfc-
          editor.org/info/rfc7357>.

Informational References

     [ARP reduction] - Shah, et. al., "ARP Broadcast Reduction for Large
          Data Centers", draft-shah-armd-arp-reduction, work in progress.

     [ChannelTunnel] - D. Eastlake, Y. Li, "TRILL: RBridge Channel Tunnel
          Protocol", draft-eastlake-trill-channel-tunnel, work in
          progress.

     [DirectoryScheme] - Dunbar, L., D. Eastlake, R. Perlman, I.
          Gashinsky, Y. Li, "TRILL": Directory Assistance Mechanisms",
          draft-dunbar-trill-scheme-for-directory-assist, work in
          progress.

     [RFC5494] - Arkko, J. and C. Pignataro, "IANA Allocation Guidelines
          for the Address Resolution Protocol (ARP)", RFC 5494, April
          2009.

     [RFC7067] - Dunbar, L., Eastlake 3rd, D., Perlman, R., and I.
          Gashinsky, "Directory Assistance Problem and High-Level Design
          Proposal", RFC 7067, November 2013.

     [RFC7178] - Eastlake 3rd, D., Manral, V., Li, Y., Aldrin, S., and D.
          Ward, "Transparent Interconnection of Lots of Links (TRILL):
          RBridge Channel Support", RFC 7178, May 2014.

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