                    TRILL: Interface Addresses APPsub-TLV
                    <draft-ietf-trill-ia-appsubtlv-00.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.

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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 [RFCfgl])) is specified for the interface
   along with the TRILL switch and, optional 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 [RFCesadi] 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 [RFCfgl]

    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 an IA APPsub-TLV.

   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 in an IS-
   IS PDU using an extended flooding scope [FSLSP] TLV, for example in
   ESADI [RFCesadi]. 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 = TBD                    |   (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 TBD[#2
   suggested] (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 [RFCesadi] message).
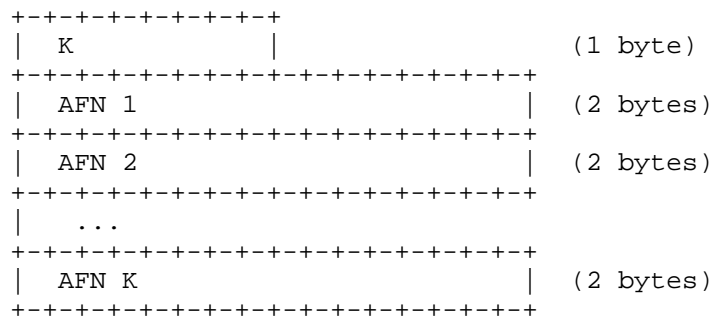
o Flags: A byte of flags as follows:

```
   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 one in the same IA APPsub-TLV if a TRILL
       switch that had learned an address locally 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] is sent depending on whether the IP
       address is IPv4 or IPv6 respectively. In both cases, these
       are sent out all the ports of the TRILL switch that offer
       end station service and are in the VLAN or FGL of the
       address set information.

    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.

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

For K in the 32 to 103 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

    $K = 32 + M + 3*v4 + 9*v6 + 36*P$

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). That equation specifies values of K from 32 through
103. Values from 104 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 104 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 but 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 [FSLSP] 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 an 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 3. If Length is 2 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 an ESADI [RFCesadi] or
    other type of 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 [RFCfgl].

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 an ESADI

[RFCesadi] or other type of message 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 [RFCfgl]) 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 [RFCesadi] or RBridge
   Channel [RFCchannel], 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

   As specified below, IANA has allocated AFN numbers and IANA is
   requested to create the TRILL IS-APPsub-TLV sub-sub-TLV subregistries
   under the TRILL Parameters Registry.

5.1 Additional AFN Number Allocation

   IANA has assigned AFN numbers as follows:

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

        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.

   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/48 or MAC/40 addresses
   present, any OUI's are ignored. If there are no OUIs, any MAC/24
   and/or MAC/40s are ignored.

   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].

   The following already allocated AFN values may be particularly useful
   for IA APPsub-TLVs:

```
     Hex      Decimal    Description   References
     -----    -------    -----------   ----------
     0001           1    IPv4
     0002           2    IPv6
     4005      16,389    48-bit MAC    [RFC7042]
     4006      16,390    64-bit MAC    [RFC7042]
```

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

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
```

Acknowledgments

   The authors gratefully acknowledge the contributions and review by
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        Linda Dunbar

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

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) = 32 + 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 ESADI [RFCesadi]) 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)=32+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 7 bytes (1 each for the type and length of the sub-sub-TLV, 2 for
the OUI AFN number, and 3 for the OUI). So, even with just three
Address Sets, there would be a small net saving of 2 bytes. The
savings would grow with a larger number of Address Sets.

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