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               IGP Extensions for Segment Routing based Enhanced VPN
                      draft-dong-lsr-sr-enhanced-vpn-05

Abstract

   Enhanced VPN (VPN+) aims to provide enhanced VPN services to support
   some application's needs of enhanced isolation and stringent
   performance requirements. VPN+ requires integration between the
   overlay VPN connectivity and the characteristics provided by the
   underlay network. A Virtual Transport Network (VTN) is a virtual
   underlay network which has a customized network topology and a set of
   network resources allocated from the physical network. A VTN could
   be used to support one or a group of VPN+ services.

   This document specifies the IGP mechanisms with necessary extensions
   to build a set of Segment Routing (SR) based VTNs. Each VTN can have
   a customized topology and a set of network resources allocated.
   Multiple VTNs may shared the same topology, and multiple VTNs may
   share the same set of network resources on some network segments.
   This allows flexible combination of network topology and network
   resource attributes to build a relatively large number of VTNs with a
   small number of logical topologies. The proposed mechanism is
   applicable to both Segment Routing with MPLS data plane (SR-MPLS) and
   segment routing with IPv6 data plane (SRv6).

Requirements Language

   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 RFC 2119 [RFC2119].

Status of This Memo

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1. Introduction

   Enhanced VPN (VPN+) is an enhancement to VPN services to support the
   needs of new applications, particularly the applications that are
   associated with 5G services. These applications require enhanced
   isolation and have more stringent performance requirements than that
   can be provided with traditional overlay VPNs. These properties
   require integration between the underlay and the overlay networks.
   [I-D.ietf-teas-enhanced-vpn] specifies the framework of enhanced VPN
   and describes the candidate component technologies in different
   network planes and layers. An enhanced VPN can be used for 5G
   network slicing, and will also be of use in more generic scenarios.

   To meet the requirement of different enhanced VPN services, a number
   of virtual underlay networks need to be created, each with a
   customized network topology and a set of network resources allocated
   from the physical network to meet the requirement of one or a group
   of VPN+ services. Such a virtual underlay network is called Virtual
   Transport Network (VTN) in [I-D.ietf-teas-enhanced-vpn].

   [I-D.ietf-spring-resource-aware-segments] introduces resource-aware
   segments by associating existing type of SIDs with network resource
   attributes (e.g. bandwidth, processing or storage resources). These
   resource-aware SIDs retain their original functionality, with the
   additional semantics of identifying the set of network resources
   available for the packet processing
   action.[I-D.ietf-spring-sr-for-enhanced-vpn] describes the use of
   resource-aware segments to build SR based VTNs. To allow the network
   controller and network nodes to perform VTN-specific explicit path
   computation and/or shortest path computation, the group of resource-
   aware SIDs allocated by network nodes to each VTN and the associated
   topology and resource attributes need to be distributed using the
   control plane.

   [I-D.dong-teas-enhanced-vpn-vtn-scalability] analyzes the scalability
   requirements and the control plane and data plane scalability
   considerations of enhanced VPN, more specifically, the scalability of
   the VTN. In order to support the increasing number of VTNs in the
   network, one proposed approach is to separate the topology and
   resource attributes of the VTN in control plane, so that the
   advertisement and processing of each type of attribute could be
   decoupled. Multiple VTNs may shared the same topology, and multiple
   VTNs may share the same set of network resources on some network
   segments., while the difference in either topology or resource

attributes makes them different VTNs. This allows flexible
combination of network topology and network resource attributes to
build a large number of VTNs with a relatively small number of
logical topologies.

This document specifies the IGP control plane mechanisms with
necessary extensions to build SR based VTNs. The proposed mechanism
is applicable to both segment routing with MPLS data plane (SR-MPLS)
and segment routing with IPv6 data plane (SRv6).

In general this approach applies to both IS-IS and OSPF, while the
specific protocol extensions and encodings are different. In the
current version of this document, the required IS-IS extensions are
described. The required OSPF extensions will be described in a
future version or in a separate document.

2. VTN Definition Advertisement

According to [I-D.ietf-teas-enhanced-vpn], a VTN has a customized
network topology and a set of dedicated or shared network resources.
Thus a VTN can be defined as the combination of a set of network
attributes, which include the topology attribute and other
attributes, such as the network resources. IS-IS Virtual Transport
Network Definition (VTND) sub-TLV is used to advertise the definition
of a VTN. It is a sub-TLV of the IS-IS Router-Capability TLV 242 as
defined in [RFC7981].

The format of IS-IS VTND sub-TLV is as below:
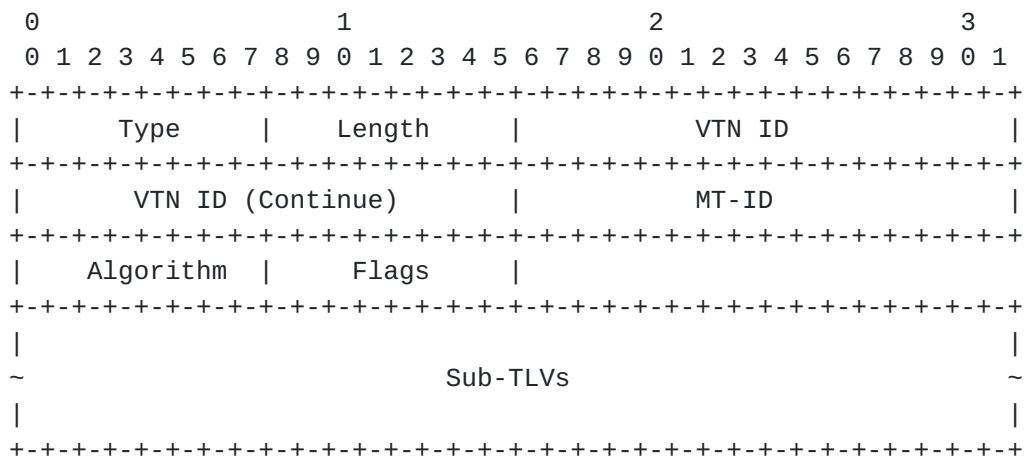
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |            VTN ID             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       VTN ID (Continue)       |            MT-ID              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Algorithm  |     Flags     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                          Sub-TLVs                             ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where:

o Type: TBD

   o Length: The length of the value field of the sub-TLV. It is
      variable dependent on the included sub-TLVs.

   o VTN ID: A global significant 32-bit identifier which is used to
      identify a VTN.

   o MT-ID: 16-bit field which indicates the multi-topology identifier
      as defined in [RFC5120]. The first 4-bit are set to zero.

   o Algorithm: 8-bit identifier which indicates the algorithm which
      applies to this VTN. It can be either a normal algorithm
      [RFC8402] or a Flex-Algorithm [I-D.ietf-lsr-flex-algo].

   o Flags: 8-bit flags. Currently all the flags are reserved for
      future use. They SHOULD be set to zero on transmission and MUST
      be ignored on receipt.

   o Sub-TLVs: optional sub-TLVs to specify the additional attributes
      of a VTN. Currently no sub-TLV is defined in this document.

   The VTND Sub-TLV MAY be advertised in an LSP of any number. A node
   MUST NOT advertise more than one VTND Sub-TLV for a given VTN ID.

3. Advertisement of VTN Topology Attribute

   This section describes the mechanisms used to advertise the topology
   attribute of SR based VTNs. Basically the topology attribute of a
   VTN can be determined by the MT-ID and/or the algorithm ID included
   in the VTN definition. In practice, it could be described using two
   optional approaches.

   The first approach is to use Multi-Topology Routing (MTR) [RFC4915]
   [RFC5120] with the segment routing extensions to advertise the
   topology associated with the SR based VTNs. Different algorithms MAY
   be used to further specify the computation algorithm or the metric
   type used for path computation within the topology. Multiple VTNs
   can be associated with the same <topology, algorithm>, and the IGP
   computation with the <topology, algorithm> tuple can be shared by
   these VTNs.

   The second approach is to use Flex-Algo [I-D.ietf-lsr-flex-algo] to
   describe the topological constraints of SR based VTNs on a shared
   network topology (e.g. the default topology). Multiple VTNs can be
   associated with the same Flex-Algo, and the IGP computation with this
   Flex-Algo can be shared.

3.1. MTR based Topology Advertisement

   Multi-Topology Routing (MTR) has been defined in [RFC4915] and
   [RFC5120] to create different network topologies in one network. It
   also has the capability of specifying customized attributes for each
   topology. The traditional use cases of multi-topology are to
   maintain separate topologies for unicast and multicast services, or
   to create different topologies for IPv4 and IPv6 in a network. There
   are some limitations when MTR is used with native IP forwarding, the
   considerations about MT based IP forwarding are described in
   [RFC5120].

   MTR can be used with SR-MPLS data plane. [RFC8667] specifies the IS-
   IS extensions to support SR-MPLS data plane, in which the Prefix-SID
   sub-TLVs can be carried in IS-IS TLV 235 (MT IP Reachability) and TLV
   237 (MT IPv6 IP Reachability), and the Adj-SID sub-TLVs can be
   carried in IS-IS TLV 222 (MT-ISN) and TLV 223 (MT IS Neighbor
   Attribute).

   MTR can also be used with SRv6 data plane.
   [I-D.ietf-lsr-isis-srv6-extensions] specifies the IS-IS extensions to
   support SRv6 data plane, in which the MT-ID is carried in the SRv6
   Locator TLV. The SRv6 End SIDs are carried as sub-TLVs in the SRv6
   Locator TLV, and inherit the topology/algorithm from the parent
   locator. The SRv6 End.X SIDs are carried as sub-TLVs in the IS-IS
   TLV 222 (MT-ISN) and TLV 223 (MT IS Neighbor Attribute), and inherit
   the topology/algorithm from the parent locator.

   These IGP extensions for SR-MPLS and SRv6 can be used to advertise
   and build the topology of SR based VTNs.

   An algorithm ID MAY be used to further specify the computation
   algorithm or the metric type used for path computation within the
   topology.

3.2. Flex-Algo based Topology Advertisement

   [I-D.ietf-lsr-flex-algo] specifies the mechanisms to provide
   distributed computation of constraint-based paths, and how the SR-
   MPLS prefix-SIDs and SRv6 locators can be used to steer packets along
   the constraint-based paths.

   The Flex-Algo Definition (FAD) can be used to describe the
   topological constraints for path computation on a network topology.
   According to the network nodes' participation of a Flex-Algo, and the
   rules of including or excluding specific Administrative Groups
   (colors) and the Shared Risk Link Groups (SRLGs), the topology of a

VTN can be determined using the associated Flex-Algo on a particular
topology (e.g. the default topology).

With the mechanisms defined in[RFC8667] [I-D.ietf-lsr-flex-algo],
prefix-SID advertisement can be associated with a <topology,
algorithm> tuple, in which the algorithm can be a Flex-Algo. This
allows network nodes to use the prefix-SID to steer traffic along
distributed computed paths according to the identified Flex-Algo in
the topology.

[I-D.ietf-lsr-isis-srv6-extensions] specifies the IS-IS extensions to
support SRv6 data plane, in which the SRv6 locators advertisement can
be associated with a specific topology and a specific algorithm,
which can be a Flex-Algo. With the mechanism defined in
[I-D.ietf-lsr-flex-algo], The SRv6 locator can be used to steer
traffic along distributed computed paths according to the identified
Flex-Algo in the topology. In addition, topology/algorithm specific
SRv6 End SID and End.X SID can be used to enforce traffic over the
LFA computed backup path.

Multiple Flex-Algos MAY be defined to describe the topological
constraints on a shared network topology (e.g. the default topology).

4. Advertisement of VTN Resource Attribute

This section specifies the mechanism to advertise the network
resource attributes associated with the VTNs. The mechanism of
advertising the link resources and attributes associated with VTNs is
described. The mechanism of advertising node resources and
attributes associated with VTNs are for further study.

On a Layer-3 interface, each VTN can be allocated with a subset of
link resources (e.g. bandwidth). A subset of link resources may be
dedicated to a VTN, or may be shared by a group of VTNs. Each subset
of link resource can be represented as a virtual layer-2 member link
under the Layer-3 interface, and the Layer-3 interface is considered
as a virtual Layer-2 bundle. The Layer-3 interface may also be a
physical Layer 2 link bundle, in this case a subset of link resources
allocated to a VTN may be provided by one of the physical Layer-2
member links.

[RFC8668] describes the IS-IS extensions to advertise the link
attributes of the Layer 2 member links which comprise a Layer 3
interface. Such mechanism can be extended to advertise the
attributes of each physical or virtual member links, and its
associated VTNs.

A new flag "V" (Virtual) is defined in the flag field of the Parent
L3 Neighbor Descriptor in the L2 Bundle Member Attributes TLV (25).

```
          0 1 2 3 4 5 6 7
         +-+-+-+-+-+-+-+-+
         |P|V|           |
         +-+-+-+-+-+-+-+-+
```

V flag: When the V flag is set, it indicates the member links under
the Parent L3 link are virtual member links. When the V flag is
clear, it indicates the member links are physical member links. This
flag may be used to determine whether all the member links share
fates with the parent interface.

A new VTN-ID sub-TLV is carried under the L2 Bundle Attribute
Descriptors to describe the mapping relationship between the VTNs and
the virtual or physical member links. As one or more VTNs may use
the same set of link resource on a specific network segment, these
VTN IDs will be advertised under the same virtual or physical member
link.

The format of the VTN-ID Sub-TLV is as below:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |    Length     |             Flags             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                           VTN ID-1                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                             ...                              ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                           VTN ID-n                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where:

o Type: TBD

o Length: The length of the value field of the sub-TLV. It is
   variable dependent on the number of VTN IDs included.

o Flags: 16 bit flags. All the bits are reserved for future use,
   which SHOULD be set to 0 on transmission and MUST be ignored on
   receipt.

o VTN IDs: One or more 32-bit identifier to identify the VTNs this
   member link belongs to.

Each physical or virtual member link MAY be associated with a
different group of VTNs. Thus each L2 Bundle Attribute Descriptor
may carry the link local identifier and attributes of only one Layer
2 memer link. Multiple L2 Bundle Attribute Descriptors will be used
to carry the attributes and the associated VTN-IDs of all the Layer 2
member links.

The TE attributes of each virtual or physical member link, such as
the bandwidth attributes and the SR SIDs, can be advertised using the
mechanism as defined in [RFC8668].

5. Advertisement of VTN specific Data Plane Identifiers

In order to steer packets to the VTN-specific paths which are
computed taking the topology and network resources of the VTN as the
constraints, some fields in the data packet needs to be used to infer
or identify the VTN the packet belongs to. As multiple VTNs may
share the same topology or Flex-Algo, the topology/Flex-Algo specific
SR SIDs or Locators cannot be used to distinguish the packets which
belong to different VTNs. Some additional data plane identifiers
would be needed to identify the VTN a packet belongs to.

This section describes the mechanisms to advertise the VTN
identifiers in different data plane encapsulations.

5.1. Advertisement of VTN-specific SR-MPLS SIDs

With SR-MPLS data plane, the VTN identification information can be
implicitly carried in the VTN-specific SIDs. Each node SHOULD
allocate a unique Prefix-SID for each VTN it participates in. On a
Layer-3 interface, if each Layer 2 member link is associated with
only one VTN, the adj-SIDs of the L2 member links could also identify
the VTNs. If a member link is associated with multiple VTNs, VTN-
specific adj-SIDs MAY need to be allocated to help the VTN-specific
local protection.

A new VTN-specific prefix-SID sub-TLV is defined to advertise the
prefix-SID and its associated VTN. This sub-TLV may be advertised as
a sub-TLV of the following TLVs:

   TLV-135 (Extended IPv4 Reachability) defined in [RFC5305].

   TLV-235 (MT IP Reachability) defined in [RFC5120].

   TLV-236 (IPv6 IP Reachability) defined in [RFC5308].

   TLV-237 (MT IPv6 IP Reachability) defined in [RFC5120].

The format of the sub-TLV is shown as below:
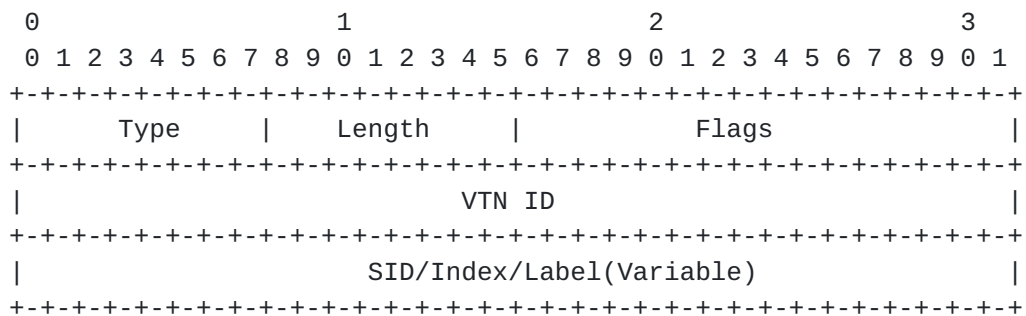
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |             Flags             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            VTN ID                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     SID/Index/Label(Variable)                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where:

o Type: TBD

o Length: The length of the value field of the sub-TLV. It is
   variable dependent on the length of the SID/Index/Label field.

o Flags: 16-bit flags. The high-order 8 bits are the same as in the
   Prefix-SID sub-TLV defined in [RFC8667]. The lower-order 8 bits
   are reserved for future use, which SHOULD be set to 0 on
   transmission and MUST be ignored on receipt.

o VTN ID: A 32-bit identifier to identify the VTN this prefix-SID
   associates with.

o SID/Index/Label: The same as defined in [RFC8667].

One or more of VTN-specific Prefix-SID sub-TLVs MAY be carried in the
Multi-topology IP Reachability TLVs (TLV 235 or TLV 237), the MT-ID
of the TLV SHOULD be the same as the MT-ID in the definition of these
VTNs.

A new VTN-specific Adj-SID sub-TLV is defined to advertise the adj-
SID and its associated VTN. This sub-TLV may be advertised as a sub-
TLV of the following TLVs:

   TLV-22 (Extended IS reachability) [RFC5305]

   TLV-23 (IS Neighbor Attribute) [RFC5311]

   TLV-25 (L2 Bundle Member Attributes) [RFC8668]

   TLV-141 (Inter-AS Reachability Information) [RFC5316]

   TLV-222 (MT ISN) [RFC5120]

   TLV-223 (MT IS Neighbor Attribute) [RFC5311]

The format of the sub-TLV is shown as below:

```
  0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |     Type      |    Length     |             Flags             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                            VTN ID                             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                     SID/Index/Label(Variable)                 |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where:

o Type: TBD

o Length: The length of the value field of the sub-TLV. It is
   variable dependent on the length of the SID/Index/Label field.

o Flags: 16-bit flags. The high-order 8 bits are the same as in the
   Adj-SID sub-TLV defined in [RFC8667]. The lower-order 8 bits are
   reserved for future use, which SHOULD be set to 0 on transmission
   and MUST be ignored on receipt.

o VTN ID: A 32-bit local identifier to identify the VTN this Adj-SID
   associates with.

o SID/Index/Label: The same as defined in [RFC8667].

One or more VTN-specific Adj-SID sub-TLV MAY be carried in the Multi-
topology ISN or Multi-topology IS Attribute TLVs (TLV 222 or TLV
223), the MT-ID of the TLV SHOULD be the same as the MT-ID in the
definition of these VTNs.

5.2. Advertisement of VTN-specific SRv6 Locators and SIDs

   With SRv6 data plane, the VTN identification information can be
   implicitly or explicitly carried in the SRv6 Locator of the
   corresponding VTN, this is to ensure that all network nodes
   (including both the end nodes and the transit nodes) can identify the
   VTN to which a packet belongs to. Network nodes SHOULD allocate VTN-
   specific Locators for each VTN it participates in. The VTN-specific
   Locators are used as the covering prefix of VTN-specific SRv6 End
   SIDs, End.X SIDs and other types of SIDs.

   Each VTN-specific SRv6 Locator MAY be advertised in a separate TLV.
   When a group of VTNs share the same topology/algorithm, the topology/
   algorithm specific Locator is the covering prefix of such group of
   VTN-specific Locators. Then the advertisement of VTN-specific
   locators can be optimized to reduce the amount of Locator TLVs
   advertised in the control plane.

   A new VTN locator-block sub-TLV under the SRv6 Locator TLV is defined
   to advertise a set of sub-blocks which follows the topology/algorithm
   specific Locator. Each VTN locator-block value is assigned to one of
   the VTNs which share the same topology/algorithm.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Type      |    Length     | Number of VTNs| Block Length  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                           VTN ID #1                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                      Locator Block Value                      ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                             ...                              ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                           VTN ID #n                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                      Locator Block Value                      ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Where:

   o Type: TBD

   o Length: The length of the value field of the sub-TLV. It is
      variable dependent on the number of VTNs and the Block Length.

   o Number of VTNs: The number of VTNs which share the same topology/
      algorithm specific Locator as the covering prefix.

o Block Length: The length of the VTN locator-block whih follows the
   length of the topology/algorithm specific Locator.

o VTN ID: A 32-bit local identifier to identify the VTN the locator-
   block is associates with.

o Block Value: The value of the VTN locator-block for each VTN.

With the VTN locator-block sub-TLV, the VTN-specific Locator can be
obtained by concatenating the topology/algorithm specific locator and
the locator-block value advertised for the VTN.

5.3. Advertisement of Dedicated Data Plane VTN IDs

As the number of VTNs increases, with the mechanism described in
[I-D.ietf-spring-sr-for-enhanced-vpn], the number of SR SIDs and SRv6
Locators allocated for different VTNs would also increase. In
network scenarios where the number of SIDs or Locators becomes a
concern, some data plane optimization may be needed to reduce the
amount of SR SIDs and Locators allocated. As described in
[I-D.dong-teas-enhanced-vpn-vtn-scalability], one approach is to
decouple the data plane identifiers used for topology based
forwarding and the identifiers used for the VTN-specific processing.
Thus a dedicated data plane VTN-ID could be encapsulated in the
packet. One possible encapsulation of VTN-ID in IPv6 data plane is
proposed in [I-D.dong-6man-enhanced-vpn-vtn-id]. One possible
encapsulation of VTN-ID in MPLS data plane is proposed in
[I-D.li-mpls-enhanced-vpn-vtn-id].

In that case, the VTN-ID encapsulated in data plane can have the same
value as the VTN-ID in control plane, so that the overhead of
advertising the mapping between the control plane VTN-IDs and the
corresponding data plane identifiers could be saved.

6. Security Considerations

This document introduces no additional security vulnerabilities to
IS-IS.

The mechanism proposed in this document is subject to the same
vulnerabilities as any other protocol that relies on IGPs.

7. IANA Considerations

IANA is requested to assign a new code point in the "sub-TLVs for TLV
242" registry.

    Type: TBD1
    Description: Virtual Transport Network Definition

    IANA is requested to assign two new code points in the "sub-TLVs for
    TLVs 22, 23, 25, 141, 222, and 223" registry.

    Type: TBD2
    Description: Virtual Transport Network Identifiers

    Type: TBD3
    Description: VTN-specific Adj-SID

    IANA is requested to assign two new code points in the "Sub-TLVs for
    TLVs 27, 135, 235, 236 and 237 registry".

    Type: TBD4
    Description: VTN-specific Prefix-SID

    Type: TBD5
    Description: VTN locator-block

8. Acknowledgments

    The authors would like to thank Mach Chen and Dean Cheng for their
    review and discussion of this document.

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9.1. Normative References

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