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BGP Overlay Services Based on Segment Routing over IPv6 (SRv6)

Abstract

   This document defines procedures and messages for SRv6-based BGP
   services, including Layer 3 Virtual Private Network (L3VPN), Ethernet
   VPN (EVPN), and Internet services. It builds on "BGP/MPLS IP Virtual
   Private Networks (VPNs)" (RFC 4364) and "BGP MPLS-Based Ethernet VPN"
   (RFC 7432).

Status of This Memo

   This is an Internet Standards Track document.

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   Internet Engineering Steering Group (IESG). Further information on
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1. Introduction

   SRv6 refers to Segment Routing instantiated on the IPv6 data plane
   [RFC8402].

   BGP is used to advertise the reachability of prefixes of a particular
   service from an egress Provider Edge (PE) to ingress PE nodes.

   SRv6-based BGP services refer to the Layer 3 (L3) and Layer 2 (L2)
   overlay services with BGP as the control plane and SRv6 as the data
   plane. This document defines procedures and messages for SRv6-based
   BGP services, including L3VPN, EVPN, and Internet services. It
   builds on "BGP/MPLS IP Virtual Private Networks (VPNs)" [RFC4364] and
   "BGP MPLS-Based Ethernet VPN" [RFC7432].

   SRv6 SID refers to an SRv6 Segment Identifier, as defined in
   [RFC8402].

   SRv6 Service SID refers to an SRv6 SID associated with one of the
   service-specific SRv6 Endpoint Behaviors on the advertising PE
   router, such as (but not limited to) End.DT (look up in the Virtual
   Routing and Forwarding (VRF) table) or End.DX (cross-connect to a
   next hop) behaviors in the case of L3VPN service, as defined in
   [RFC8986]. This document describes how existing BGP messages between
   PEs may carry SRv6 Service SIDs to interconnect PEs and form VPNs.

   To provide SRv6 service with best-effort connectivity, the egress PE
   signals an SRv6 Service SID with the BGP overlay service route. The
   ingress PE encapsulates the payload in an outer IPv6 header where the
   destination address is the SRv6 Service SID provided by the egress
   PE. The underlay between the PEs only needs to support plain IPv6
   forwarding [RFC8200].

   To provide SRv6 service in conjunction with an underlay Service Level
   Agreement (SLA) from the ingress PE to the egress PE, the egress PE
   colors the overlay service route with a Color Extended Community
   [RFC9012] for steering flows for those routes, as specified in
   Section 8 of [SEGMENT-ROUTING-POLICY]. The ingress PE encapsulates
   the payload packet in an outer IPv6 header with the SR Policy segment

list associated with the related SLA along with the SRv6 Service SID
associated with the route using the Segment Routing Header (SRH)
[RFC8754]. The underlay nodes whose SRv6 SIDs are part of the SRH
segment list MUST support the SRv6 data plane.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and
"OPTIONAL" in this document are to be interpreted as described in
BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all
capitals, as shown here.

2. SRv6 Services TLVs

This document extends the use of the BGP Prefix-SID attribute
[RFC8669] to carry SRv6 SIDs and their associated information with
the BGP address families that are listed further in this section.

The SRv6 Service TLVs are defined as two new TLVs of the BGP Prefix-
SID attribute to achieve signaling of SRv6 SIDs for L3 and L2
services.

SRv6 L3 Service TLV:
   This TLV encodes Service SID information for SRv6-based L3
   services. It corresponds to the equivalent functionality provided
   by an MPLS label when received with a Layer 3 service route, as
   defined in [RFC4364], [RFC4659], [RFC8950], and [RFC9136]. Some
   SRv6 Endpoint Behaviors that may be encoded are, but not limited
   to, End.DX4, End.DT4, End.DX6, End.DT6, and End.DT46.

SRv6 L2 Service TLV:
   This TLV encodes Service SID information for SRv6-based L2
   services. It corresponds to the equivalent functionality provided
   by an MPLS label for Ethernet VPN (EVPN) Route Types for Layer 2
   services, as defined in [RFC7432]. Some SRv6 Endpoint Behaviors
   that may be encoded are, but not limited to, End.DX2, End.DX2V,
   End.DT2U, and End.DT2M.

When an egress PE is enabled for BGP Services over the SRv6 data
plane, it signals one or more SRv6 Service SIDs enclosed in an SRv6
Service TLV(s) within the BGP Prefix-SID attribute attached to
Multiprotocol BGP (MP-BGP) Network Layer Reachability Information
(NLRI) defined in [RFC4760], [RFC4659], [RFC8950], [RFC7432],
[RFC4364], and [RFC9136], where applicable, as described in Sections
5 and 6.

The support for BGP Multicast VPN (MVPN) Services [RFC6513] with SRv6
is outside the scope of this document.

The following depicts the SRv6 Service TLVs encoded in the BGP
Prefix-SID attribute:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   TLV Type    |          TLV Length           |   RESERVED    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   SRv6 Service Sub-TLVs                                      //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
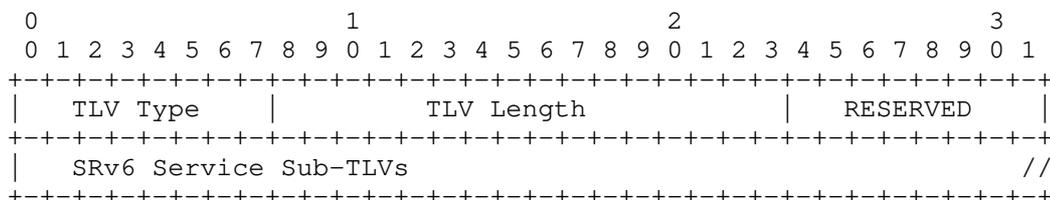
   Figure 1: SRv6 Service TLVs

TLV Type (1 octet):
   This field is assigned a value from IANA's "BGP Prefix-SID TLV
   Types" subregistry. It is set to 5 for the SRv6 L3 Service TLV.
   It is set to 6 for the SRv6 L2 Service TLV.

TLV Length (2 octets):
   This field specifies the total length, in octets, of the TLV
   Value.

RESERVED (1 octet):
   This field is reserved; it MUST be set to 0 by the sender and
   ignored by the receiver.

SRv6 Service Sub-TLVs (variable):
   This field contains SRv6 service-related information and is
   encoded as an unordered list of Sub-TLVs whose format is described
   below.

A BGP speaker receiving a route containing the BGP Prefix-SID
attribute with one or more SRv6 Service TLVs observes the following
rules when advertising the received route to other peers:

* If the BGP next hop is unchanged during the advertisement, the
   SRv6 Service TLVs, including any unrecognized Types of Sub-TLV and
   Sub-Sub-TLV, SHOULD be propagated further. In addition, all
   Reserved fields in the TLV, Sub-TLV, or Sub-Sub-TLV MUST be
   propagated unchanged.

* If the BGP next hop is changed, the TLVs, Sub-TLVs, and Sub-Sub-
   TLVs SHOULD be updated with the locally allocated SRv6 SID
   information. Any received Sub-TLVs and Sub-Sub-TLVs that are
   unrecognized MUST be removed.

3. SRv6 Service Sub-TLVs

   The format of a single SRv6 Service Sub-TLV is depicted 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SRv6 Service  | SRv6 Service          | SRv6 Service //
| Sub-TLV       | Sub-TLV               | Sub-TLV     //
| Type          | Length                | Value       //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
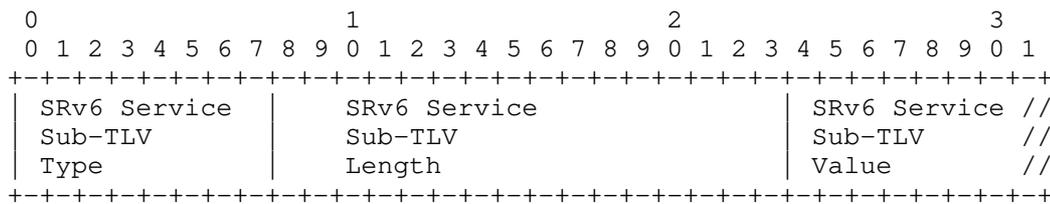
                   Figure 2: SRv6 Service Sub-TLVs

SRv6 Service Sub-TLV Type (1 octet):
   This field identifies the type of SRv6 service information. It is
   assigned a value from IANA's "SRv6 Service Sub-TLV Types"
   subregistry.

SRv6 Service Sub-TLV Length (2 octets):
   This field specifies the total length, in octets, of the Sub-TLV
   Value field.

SRv6 Service Sub-TLV Value (variable):
   This field contains data specific to the Sub-TLV Type. In
   addition to fixed-length data, it contains other properties of the
   SRv6 service encoded as a set of SRv6 Service Data Sub-Sub-TLVs
   whose format is described in Section 3.2 below.

3.1. SRv6 SID Information Sub-TLV

   SRv6 Service Sub-TLV Type 1 is assigned for the SRv6 SID Information
   Sub-TLV. This Sub-TLV contains a single SRv6 SID along with its
   properties. Its encoding is depicted 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SRv6 Service  | SRv6 Service          |               |
| Sub-TLV       | Sub-TLV               |               |
| Type=1        | Length                | RESERVED1     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SRv6 SID Value (16 octets)                                 //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Svc SID Flags | SRv6 Endpoint Behavior    | RESERVED2     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
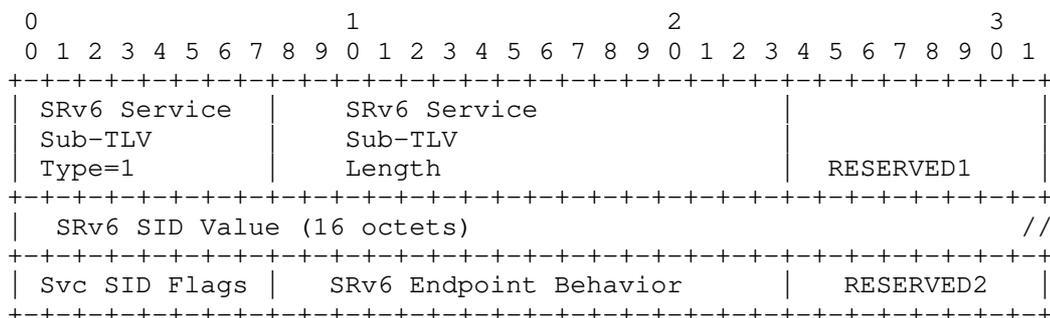
```
|   SRv6 Service Data Sub-Sub-TLVs                                //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                    Figure 3: SRv6 SID Information Sub-TLV

   SRv6 Service Sub-TLV Type (1 octet):
      This field is set to 1 to represent the SRv6 SID Information Sub-
      TLV.

   SRv6 Service Sub-TLV Length (2 octets):
      This field contains the total length, in octets, of the Value
      field of the Sub-TLV.

   RESERVED1 (1 octet):
      This field MUST be set to 0 by the sender and ignored by the
      receiver.

   SRv6 SID Value (16 octets):
      This field encodes an SRv6 SID, as defined in [RFC8986].

   SRv6 Service SID Flags (1 octet):
      This field encodes SRv6 Service SID Flags -- none are currently
      defined. It MUST be set to 0 by the sender and any unknown flags
      MUST be ignored by the receiver.

   SRv6 Endpoint Behavior (2 octets):
      This field encodes the SRv6 Endpoint Behavior codepoint value that
      is associated with the SRv6 SID. The codepoints used are from
      IANA's "SRv6 Endpoint Behaviors" subregistry under the "Segment
      Routing" registry that was introduced by [RFC8986]. The opaque
      SRv6 Endpoint Behavior (i.e., value 0xFFFF) MAY be used when the
      advertising router wishes to abstract the actual behavior of its
      locally instantiated SRv6 SID.

   RESERVED2 (1 octet):
      This field MUST be set to 0 by the sender and ignored by the
      receiver.

   SRv6 Service Data Sub-Sub-TLV Value (variable):
      This field is used to advertise properties of the SRv6 SID. It is
      encoded as a set of SRv6 Service Data Sub-Sub-TLVs.

   The choice of SRv6 Endpoint Behavior of the SRv6 SID is entirely up
   to the originator of the advertisement. While Sections 5 and 6 list
   the SRv6 Endpoint Behaviors that are normally expected to be used by
   the specific route advertisements, the reception of other SRv6
   Endpoint Behaviors (e.g., new behaviors that may be introduced in the
   future) is not considered an error. An unrecognized SRv6 Endpoint
   Behavior MUST NOT be considered invalid by the receiver, except for
   behaviors that involve the use of arguments (refer to Section 3.2.1
   for details on argument validation). An implementation MAY log a
   rate-limited warning when it receives an unexpected behavior.

   When multiple SRv6 SID Information Sub-TLVs are present, the ingress
   PE SHOULD use the SRv6 SID from the first instance of the Sub-TLV.
   An implementation MAY provide a local policy to override this
   selection.

3.2. SRv6 Service Data Sub-Sub-TLVs

   The format of the SRv6 Service Data Sub-Sub-TLV is depicted 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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Service Data |    Sub-Sub-TLV Length          |Sub-Sub TLV //
   | Sub-Sub-TLV  |                                | Value      //
   | Type         |                                |            //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
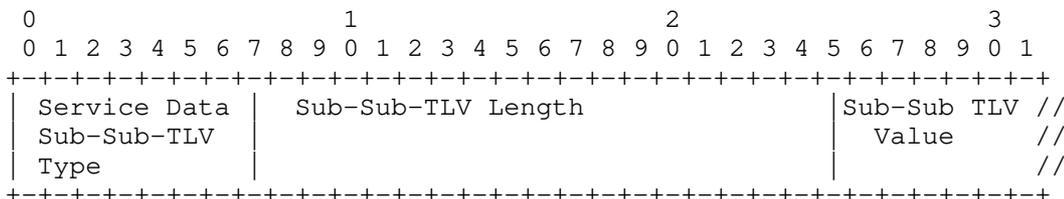
                   Figure 4: SRv6 Service Data Sub-Sub-TLVs

SRv6 Service Data Sub-Sub-TLV Type (1 octet):
   This field identifies the type of Sub-Sub-TLV. It is assigned a
   value from IANA's "SRv6 Service Data Sub-Sub-TLV Types"
   subregistry.

SRv6 Service Data Sub-Sub-TLV Length (2 octets):
   This field specifies the total length, in octets, of the Sub-Sub-
   TLV Value field.

SRv6 Service Data Sub-Sub-TLV Value (variable):
   This field contains data specific to the Sub-Sub-TLV Type.

3.2.1. SRv6 SID Structure Sub-Sub-TLV

   SRv6 Service Data Sub-Sub-TLV Type 1 is assigned for the SRv6 SID
   Structure Sub-Sub-TLV. The SRv6 SID Structure Sub-Sub-TLV is used to
   advertise the lengths of the individual parts of the SRv6 SID, as
   defined in [RFC8986]. The terms Locator Block and Locator Node
   correspond to the B and N parts, respectively, of the SRv6 Locator
   that is defined in Section 3.1 of [RFC8986]. It is carried as Sub-
   Sub-TLV in the SRv6 SID Information Sub-TLV.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SRv6 Service  | SRv6 Service      | Locator Block |
| Data Sub-Sub  | Data Sub-Sub-TLV  | Length        |
| -TLV Type=1   | Length            |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Locator Node  | Function      | Argument      | Transposition |
| Length        | Length        | Length        | Length        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Transposition |
| Offset        |
+-+-+-+-+-+-+-+-+
```
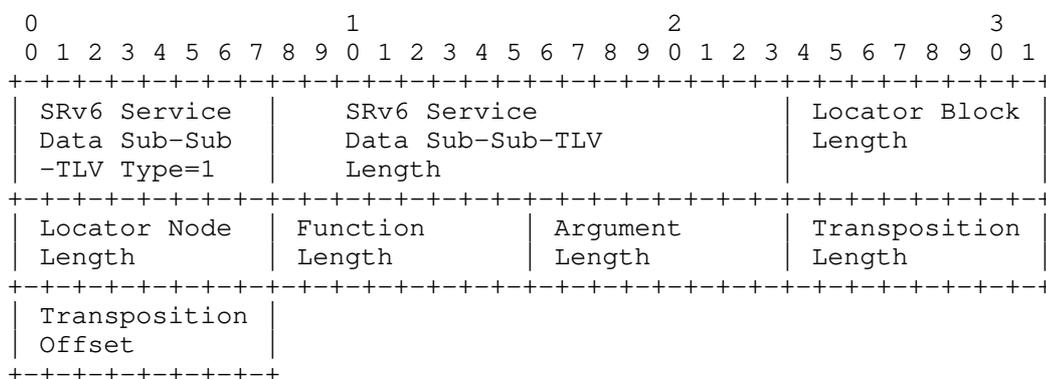
                 Figure 5: SRv6 SID Structure Sub-Sub-TLV

   SRv6 Service Data Sub-Sub-TLV Type (1 octet):
      This field is set to 1 to represent the SRv6 SID Structure Sub-
      Sub-TLV.

   SRv6 Service Data Sub-Sub-TLV Length (2 octets):
      This field contains a total length of 6 octets.

   Locator Block Length (1 octet):
      This field contains the length of the SRv6 SID Locator Block in
      bits.

   Locator Node Length (1 octet):
      This field contains the length of the SRv6 SID Locator Node in
      bits.

   Function Length (1 octet):
      This field contains the length of the SRv6 SID Function in bits.

   Argument Length (1 octet):
      This field contains the length of the SRv6 SID Argument in bits.

   Transposition Length (1 octet):
      This field is the size in bits for the part of the SID that has
      been transposed (or shifted) into an MPLS Label field.

   Transposition Offset (1 octet):
      This field is the offset position in bits for the part of the SID
      that has been transposed (or shifted) into an MPLS Label field.

   Section 4 describes mechanisms for the signaling of the SRv6 Service
   SID by transposing a variable part of the SRv6 SID value and carrying
   this variable part in existing MPLS Label fields to achieve more

efficient packing of those service prefix NLRIs in BGP update
messages. The SRv6 SID Structure Sub-Sub-TLV contains appropriate
length fields when the SRv6 Service SID is signaled in split parts to
enable the receiver to put together the SID accurately.

Transposition Offset indicates the bit position, and Transposition
Length indicates the number of bits that are being taken out of the
SRv6 SID value and encoded in the MPLS Label field. The bits that
have been shifted out MUST be set to 0 in the SID value.

A Transposition Length of 0 indicates nothing is transposed and that
the entire SRv6 SID value is encoded in the SID Information Sub-TLV.
In this case, the Transposition Offset MUST be set to 0.

The size of the MPLS Label field limits the bits transposed from the
SRv6 SID value into it. For example, the size of the MPLS Label
field is 20 bits in [RFC4364] and [RFC8277], and the size is 24 bits
in [RFC7432].

As defined in [RFC8986], the sum of the Locator Block Length (LBL),
Locator Node Length (LNL), Function Length (FL), and Argument Length
(AL) fields MUST be less than or equal to 128 and greater than the
sum of Transposition Offset and Transposition Length.

As an example, consider that the sum of the Locator Block and the
Locator Node parts is 64. For an SRv6 SID where the entire Function
part of size 16 bits is transposed, the transposition offset is set
to 64 and the transposition length is set to 16. While for an SRv6
SID for which the FL is 24 bits and only the lower order 20 bits are
transposed (e.g., due to the limit of the MPLS Label field size), the
transposition offset is set to 68 and the transposition length is set
to 20.

BGP speakers that do not support this specification may misinterpret,
on the reception of an SRv6-based BGP service route update, the part
of the SRv6 SID encoded in an MPLS Label field(s) as MPLS label
values for MPLS-based services. Implementations supporting this
specification MUST provide a mechanism to control the advertisement
of SRv6-based BGP service routes on a per-neighbor and per-service
basis. The details of deployment designs and implementation options
are outside the scope of this document.

Arguments may be generally applicable for SIDs of only specific SRv6
Endpoint Behaviors (e.g., End.DT2M); therefore, the AL MUST be set to
0 for SIDs where the Argument is not applicable. A receiver is
unable to validate the applicability of arguments for SRv6 Endpoint
Behaviors that are unknown to it and hence MUST ignore SRv6 SIDs with
arguments (indicated by a non-zero AL) with unknown SRv6 Endpoint
Behaviors. For SIDs corresponding to an SRv6 Endpoint Behavior that
is known, a receiver MUST validate that the consistency of the AL
with the specific SRv6 Endpoint Behavior definition.

4. Encoding SRv6 SID Information

The SRv6 Service SID(s) for a BGP service prefix is carried in the
SRv6 Services TLVs of the BGP Prefix-SID attribute.

For certain types of BGP Services, like L3VPN where a per-VRF SID
allocation is used (i.e., End.DT4 or End.DT6 behaviors), the same SID
is shared across multiple NLRIs, thus providing efficient packing.
However, for certain other types of BGP Services, like EVPN Virtual
Private Wire Service (VPWS) where a per-PW SID allocation is required
(i.e., End.DX2 behavior), each NLRI would have its own unique SID,
thereby resulting in inefficient packing.

To achieve efficient packing, this document allows either 1) the
encoding of the SRv6 Service SID as a whole in the SRv6 Services TLVs
or 2) the encoding of only the common part of the SRv6 SID (e.g.,
Locator) in the SRv6 Services TLVs and the encoding of the variable
(e.g., Function or Argument parts) in the existing label fields
specific to that service encoding. This later form of encoding is

referred to as the Transposition Scheme, where the SRv6 SID Structure
Sub-Sub-TLV describes the sizes of the parts of the SRv6 SID and also
indicates the offset of the variable part along with its length in
the SRv6 SID value. The use of the Transposition Scheme is
RECOMMENDED for the specific service encodings that allow it, as
described further in Sections 5 and 6.

As an example, for the EVPN VPWS service prefix described further in
Section 6.1.2, the Function part of the SRv6 SID is encoded in the
MPLS Label field of the NLRI, and the SID value in the SRv6 Services
TLV carries only the Locator part with the SRv6 SID Structure Sub-
Sub-TLV. The SRv6 SID Structure Sub-Sub-TLV defines the lengths of
Locator Block, Locator Node, and Function parts (Arguments are not
applicable for the End.DX2 behavior). Transposition Offset indicates
the bit position, and Transposition Length indicates the number of
bits that are being taken out of the SID and put into the label
field.

In yet another example, for the EVPN Ethernet Auto-Discovery (A-D)
per Ethernet Segment (ES) route described further in Section 6.1.1,
only the Argument of the SID needs to be signaled. This Argument
part of the SRv6 SID MAY be transposed in the Ethernet Segment
Identifier (ESI) Label field of the ESI Label extended community, and
the SID value in the SRv6 Services TLV is set to 0 along with the
inclusion of the SRv6 SID Structure Sub-Sub-TLV. The SRv6 SID
Structure Sub-Sub-TLV defines the lengths of Locator Block, Locator
Node, Function, and Argument parts. The offset and length of the
Argument part SID value moved to the label field is set in
transposition offset and length of the SID Structure TLV. The
receiving router is then able to put together the entire SRv6 Service
SID (e.g., for the End.DT2M behavior), placing the label value
received in the ESI Label field of the Ethernet A-D per ES route into
the correct transposition offset and length in the SRv6 SID with the
End.DT2M behavior received for an EVPN Route Type 3 value.

5. BGP-Based L3 Service over SRv6

   BGP egress nodes (egress PEs) advertise a set of reachable prefixes.
   Standard BGP update propagation schemes [RFC4271], which may make use
   of route reflectors [RFC4456], are used to propagate these prefixes.
   BGP ingress nodes (ingress PEs) receive these advertisements and may
   add the prefix to the RIB in an appropriate VRF.

   Egress PEs that support SRv6-based L3 services advertise overlay
   service prefixes along with a Service SID enclosed in an SRv6 L3
   Service TLV within the BGP Prefix-SID attribute. This TLV serves two
   purposes -- first, it indicates that the egress PE supports SRv6
   overlay, and the BGP ingress PE receiving this route MUST perform
   IPv6 encapsulation and insert an SRH [RFC8754] when required; second,
   it indicates the value of the Service SID to be used in the
   encapsulation.

   Thus, the Service SID signaled only has local significance at the
   egress PE, where it may be allocated or configured on a per-Customer-
   Edge (CE) or per-VRF basis. In practice, the SID may encode a cross-
   connect to a specific address family table (End.DT) or next hop /
   interface (End.DX), as defined in [RFC8986].

   The SRv6 Service SID SHOULD be routable (refer to Section 3.3 of
   [RFC8986]) within the Autonomous System (AS) of the egress PE and
   serves the dual purpose of providing reachability between ingress PE
   and egress PE while also encoding the SRv6 Endpoint Behavior.

   When steering for SRv6 services is based on shortest path forwarding
   (e.g., best effort or IGP Flexible Algorithm [IGP-FLEX-ALGO]) to the
   egress PE, the ingress PE encapsulates the IPv4 or IPv6 customer
   packet in an outer IPv6 header (using H.Encaps or H.Encaps.Red
   flavors specified in [RFC8986]), where the destination address is the
   SRv6 Service SID associated with the related BGP route update.
   Therefore, the ingress PE MUST perform a resolvability check for the
   SRv6 Service SID before considering the received prefix for the BGP

best path computation. The resolvability is evaluated as per
[RFC4271]. If the SRv6 SID is reachable via more than one forwarding
table, local policy is used to determine which table to use. The
result of an SRv6 Service SID resolvability (e.g., when provided via
IGP Flexible Algorithm) can be ignored if the ingress PE has a local
policy that allows an alternate steering mechanism to reach the
egress PE. The details of such steering mechanisms are outside the
scope of this document.

For service over SRv6 core, the egress PE sets the BGP next hop to
one of its IPv6 addresses. Such an address MAY be covered by the
SRv6 Locator from which the SRv6 Service SID is allocated. The BGP
next hop is used for tracking the reachability of the egress PE based
on existing BGP procedures.

When the BGP route received at an ingress PE is colored with a Color
Extended Community and a valid SRv6 Policy is available, the steering
for service flows is performed as described in Section 8 of
[SEGMENT-ROUTING-POLICY]. When the ingress PE determines (with the
help of the SRv6 SID Structure) that the Service SID belongs to the
same SRv6 Locator as the last SRv6 SID (of the egress PE) in the SR
Policy segment list, it MAY exclude that last SRv6 SID when steering
the service flow. For example, the effective segment list of the
SRv6 Policy associated with SID list <S1, S2, S3> would be <S1, S2,
S3-Service-SID>.

5.1. IPv4 VPN over SRv6 Core

The MP_REACH_NLRI over SRv6 core is encoded according to IPv4 VPN
unicast over IPv6 core defined in [RFC8950].

The label field of IPv4-VPN NLRI is encoded as specified in [RFC8277]
with the 20-bit Label Value set to the whole or a portion of the
Function part of the SRv6 SID when the Transposition Scheme of
encoding (Section 4) is used; otherwise, it is set to Implicit NULL.
When using the Transposition Scheme, the Transposition Length MUST be
less than or equal to 20 and less than or equal to the FL.

The SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV.
The SRv6 Endpoint Behavior SHOULD be one of these: End.DX4, End.DT4,
or End.DT46.

5.2. IPv6 VPN over SRv6 Core

The MP_REACH_NLRI over SRv6 core is encoded according to IPv6 VPN
over IPv6 core, as defined in [RFC4659].

The label field of the IPv6-VPN NLRI is encoded as specified in
[RFC8277] with the 20-bit Label Value set to the whole or a portion
of the Function part of the SRv6 SID when the Transposition Scheme of
encoding (Section 4) is used; otherwise, it is set to Implicit NULL.
When using the Transposition Scheme, the Transposition Length MUST be
less than or equal to 20 and less than or equal to the FL.

The SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV.
The SRv6 Endpoint Behavior SHOULD be one of these: End.DX6, End.DT6,
or End.DT46.

5.3. Global IPv4 over SRv6 Core

The MP_REACH_NLRI over SRv6 core is encoded according to IPv4 over
IPv6 core, as defined in [RFC8950].

SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV. The
SRv6 Endpoint Behavior SHOULD be one of these: End.DX4, End.DT4, or
End.DT46.

5.4. Global IPv6 over SRv6 Core

The MP_REACH_NLRI over SRv6 core is encoded according to [RFC2545].

The SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV.
The SRv6 Endpoint Behavior SHOULD be one of these: End.DX6, End.DT6,
or End.DT46.

6. BGP-Based Ethernet VPN (EVPN) over SRv6

    [RFC7432] provides an extendable method of building an EVPN overlay.
    It primarily focuses on MPLS-based EVPNs, and [RFC8365] extends to
    IP-based EVPN overlays. [RFC7432] defines Route Types 1, 2, and 3,
    which carry prefixes and MPLS Label fields; the Label fields have a
    specific use for MPLS encapsulation of EVPN traffic. Route Type 5
    carrying MPLS label information (and thus encapsulation information)
    for an EVPN is defined in [RFC9136]. Route Types 6, 7, and 8 are
    defined in [RFC9251].

    * Ethernet Auto-Discovery (A-D) route (Route Type 1)

    * MAC/IP Advertisement route (Route Type 2)

    * Inclusive Multicast Ethernet Tag route (Route Type 3)

    * Ethernet Segment route (Route Type 4)

    * IP Prefix route (Route Type 5)

    * Selective Multicast Ethernet Tag route (Route Type 6)

    * Multicast Membership Report Synch route (Route Type 7)

    * Multicast Leave Synch route (Route Type 8)

    The specifications for other EVPN Route Types are outside the scope
    of this document.

    To support SRv6-based EVPN overlays, one or more SRv6 Service SIDs
    are advertised with Route Types 1, 2, 3, and 5. The SRv6 Service
    SID(s) per Route Type is advertised in SRv6 L3/L2 Service TLVs within
    the BGP Prefix-SID attribute. Signaling of the SRv6 Service SID(s)
    serves two purposes -- first, it indicates that the BGP egress device
    supports SRv6 overlay, and the BGP ingress device receiving this
    route MUST perform IPv6 encapsulation and insert an SRH [RFC8754]
    when required; second, it indicates the value of the Service SID(s)
    to be used in the encapsulation.

    The SRv6 Service SID SHOULD be routable (refer to Section 3.3 of
    [RFC8986]) within the AS of the egress PE and serves the dual purpose
    of providing reachability between the ingress PE and egress PE while
    also encoding the SRv6 Endpoint Behavior.

    When steering for SRv6 services is based on shortest path forwarding
    (e.g., best effort or IGP Flexible Algorithm [IGP-FLEX-ALGO]) to the
    egress PE, the ingress PE encapsulates the customer Layer 2 Ethernet
    packet in an outer IPv6 header (using H.Encaps.L2 or H.Encaps.L2.Red
    flavors specified in [RFC8986]) where the destination address is the
    SRv6 Service SID associated with the related BGP route update.
    Therefore, the ingress PE MUST perform a resolvability check for the
    SRv6 Service SID before considering the received prefix for the BGP
    best path computation. The resolvability is evaluated as per
    [RFC4271]. If the SRv6 SID is reachable via more than one forwarding
    table, local policy is used to determine which table to use. The
    result of an SRv6 Service SID resolvability (e.g., when provided via
    IGP Flexible Algorithm) can be ignored if the ingress PE has a local
    policy that allows an alternate steering mechanism to reach the
    egress PE. The details of such steering mechanisms are outside the
    scope of this document.

    For service over SRv6 core, the egress PE sets the BGP next hop to
    one of its IPv6 addresses. Such an address MAY be covered by the
    SRv6 Locator from which the SRv6 Service SID is allocated. The BGP
    next hop is used for tracking the reachability of the egress PE based
    on existing BGP procedures.

When the BGP route received at an ingress PE is colored with a Color
Extended Community and a valid SRv6 Policy is available, the steering
for service flows is performed as described in Section 8 of
[SEGMENT-ROUTING-POLICY]. When the ingress PE determines (with the
help of the SRv6 SID Structure) that the Service SID belongs to the
same SRv6 Locator as the last SRv6 SID (of the egress PE) in the SR
Policy segment list, it MAY exclude that last SRv6 SID when steering
the service flow. For example, the effective segment list of the
SRv6 Policy associated with SID list <S1, S2, S3> would be <S1, S2,
S3-Service-SID>.

6.1. Ethernet Auto-Discovery Route over SRv6 Core

Ethernet A-D routes are Route Type 1, as defined in [RFC7432], and
may be used to achieve split-horizon filtering, fast convergence, and
aliasing. EVPN Route Type 1 is also used in EVPN-VPWS as well as in
EVPN-flexible cross-connect, mainly to advertise point-to-point
service IDs.

As a reminder, EVPN Route Type 1 is encoded as follows:

```
+-----------------------------------------+
|  RD (8 octets)                          |
+-----------------------------------------+
|  Ethernet Segment Identifier (10 octets)|
+-----------------------------------------+
|  Ethernet Tag ID (4 octets)             |
+-----------------------------------------+
|  MPLS label (3 octets)                  |
+-----------------------------------------+
```
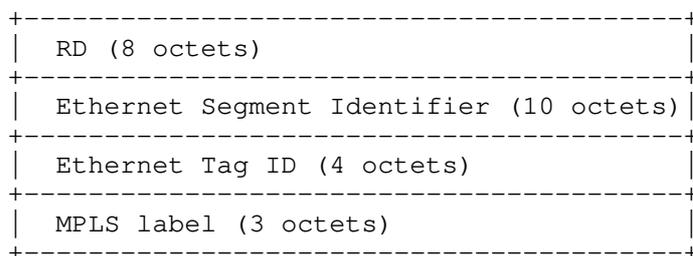
Figure 6: EVPN Route Type 1

6.1.1. Ethernet A-D per ES Route

Ethernet A-D per ES route NLRI encoding over SRv6 core is as per
[RFC7432].

The 24-bit ESI Label field of the ESI Label extended community
carries the whole or a portion of the Argument part of the SRv6 SID
when the ESI filtering approach is used along with the Transposition
Scheme of encoding (Section 4); otherwise, it is set to Implicit NULL
in the higher-order 20 bits (i.e., as 0x000030). In either case, the
value is set in the 24 bits. When using the Transposition Scheme,
the Transposition Length MUST be less than or equal to 24 and less
than or equal to the AL.

A Service SID enclosed in an SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the A-D route. The
SRv6 Endpoint Behavior SHOULD be End.DT2M. When the ESI filtering
approach is used, the Service SID is used to signal the Arg.FE2 SID
Argument for applicable End.DT2M behavior [RFC8986]. When the local-
bias approach [RFC8365] is used, the Service SID MAY be of value 0.

6.1.2. Ethernet A-D per EVI Route

Ethernet A-D per EVPN Instance (EVI) route NLRI encoding over SRv6
core is similar to what is described in [RFC7432] and [RFC8214] with
the following change:

MPLS Label:
   The 24-bit field carries the whole or a portion of the Function
   part of the SRv6 SID when the Transposition Scheme of encoding
   (Section 4) is used; otherwise, it is set to Implicit NULL in the
   higher-order 20 bits (i.e., as 0x000030). In either case, the
   value is set in the 24 bits. When using the Transposition Scheme,
   the Transposition Length MUST be less than or equal to 24 and less
   than or equal to the FL.

A Service SID enclosed in an SRv6 L2 Service TLV within the BGP

Prefix-SID attribute is advertised along with the A-D route. The
SRv6 Endpoint Behavior SHOULD be one of these: End.DX2, End.DX2V, or
End.DT2U.

6.2. MAC/IP Advertisement Route over SRv6 Core

   EVPN Route Type 2 is used to advertise unicast traffic Media Access
   Control (MAC) + IP address reachability through MP-BGP to all other
   PEs in a given EVPN instance.

   As a reminder, EVPN Route Type 2 is encoded as follows:

```
             +----------------------------------------+
             |  RD (8 octets)                         |
             +----------------------------------------+
             |  Ethernet Segment Identifier (10 octets)|
             +----------------------------------------+
             |  Ethernet Tag ID (4 octets)            |
             +----------------------------------------+
             |  MAC Address Length (1 octet)          |
             +----------------------------------------+
             |  MAC Address (6 octets)                |
             +----------------------------------------+
             |  IP Address Length (1 octet)           |
             +----------------------------------------+
             |  IP Address (0, 4, or 16 octets)       |
             +----------------------------------------+
             |  MPLS Label1 (3 octets)                |
             +----------------------------------------+
             |  MPLS Label2 (0 or 3 octets)           |
             +----------------------------------------+
```
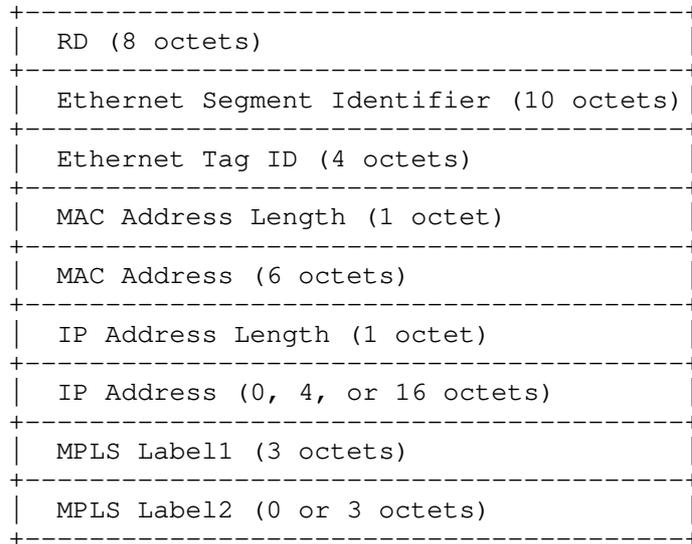
                   Figure 7: EVPN Route Type 2

   NLRI encoding over SRv6 core is similar to what is described in
   [RFC7432] with the following changes:

   MPLS Label1:
      This is associated with the SRv6 L2 Service TLV. This 24-bit
      field carries the whole or a portion of the Function part of the
      SRv6 SID when the Transposition Scheme of encoding (Section 4) is
      used; otherwise, it is set to Implicit NULL in the higher-order 20
      bits (i.e., as 0x000030). In either case, the value is set in the
      24 bits. When using the Transposition Scheme, the Transposition
      Length MUST be less than or equal to 24 and less than or equal to
      the FL.

   MPLS Label2:
      This is associated with the SRv6 L3 Service TLV. This 24-bit
      field carries the whole or a portion of the Function part of the
      SRv6 SID when the Transposition Scheme of encoding (Section 4) is
      used; otherwise, it is set to Implicit NULL in the higher-order 20
      bits (i.e., as 0x000030). In either case, the value is set in the
      24 bits. When using the Transposition Scheme, the Transposition
      Length MUST be less than or equal to 24 and less than or equal to
      the FL.

   Service SIDs enclosed in the SRv6 L2 Service TLV and optionally in
   the SRv6 L3 Service TLV within the BGP Prefix-SID attribute are
   advertised along with the MAC/IP Advertisement route.

   Described below are different types of Route Type 2 advertisements.

6.2.1. MAC/IP Advertisement Route with MAC Only

   MPLS Label1:
      This is associated with the SRv6 L2 Service TLV. This 24-bit
      field carries the whole or a portion of the Function part of the
      SRv6 SID when the Transposition Scheme of encoding (Section 4) is
      used; otherwise, it is set to Implicit NULL in the higher-order 20
      bits (i.e., as 0x000030). In either case, the value is set in the

24 bits. When using the Transposition Scheme, the Transposition
Length MUST be less than or equal to 24 and less than or equal to
the FL.

A Service SID enclosed in an SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the route. The SRv6
Endpoint Behavior SHOULD be one of these: End.DX2 or End.DT2U.

6.2.2. MAC/IP Advertisement Route with MAC+IP

MPLS Label1:
    This is associated with the SRv6 L2 Service TLV. This 24-bit
    field carries the whole or a portion of the Function part of the
    SRv6 SID when the Transposition Scheme of encoding (Section 4) is
    used; otherwise, it is set to Implicit NULL in the higher-order 20
    bits (i.e., as 0x000030). In either case, the value is set in the
    24 bits. When using the Transposition Scheme, the Transposition
    Length MUST be less than or equal to 24 and less than or equal to
    the FL.

MPLS Label2:
    This is associated with the SRv6 L3 Service TLV. This 24-bit
    field carries the whole or a portion of the Function part of the
    SRv6 SID when the Transposition Scheme of encoding (Section 4) is
    used; otherwise, it is set to Implicit NULL in the higher-order 20
    bits (i.e., as 0x000030). In either case, the value is set in the
    24 bits. When using the Transposition Scheme, the Transposition
    Length MUST be less than or equal to 24 and less than or equal to
    the FL.

An L2 Service SID enclosed in an SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the route. In
addition, an L3 Service SID enclosed in an SRv6 L3 Service TLV within
the BGP Prefix-SID attribute MAY also be advertised along with the
route. The SRv6 Endpoint Behavior SHOULD be one of these: for the L2
Service SID, End.DX2 or End.DT2U and for the L3 Service SID,
End.DT46, End.DT4, End.DT6, End.DX4, or End.DX6.

6.3. Inclusive Multicast Ethernet Tag Route over SRv6 Core

EVPN Route Type 3 is used to advertise multicast traffic reachability
information through MP-BGP to all other PEs in a given EVPN instance.

As a reminder, EVPN Route Type 3 is encoded as follows:

```
+---------------------------------------+
| RD (8 octets)                         |
+---------------------------------------+
| Ethernet Tag ID (4 octets)            |
+---------------------------------------+
| IP Address Length (1 octet)           |
+---------------------------------------+
| Originating Router's IP Address       |
|          (4 or 16 octets)             |
+---------------------------------------+
```
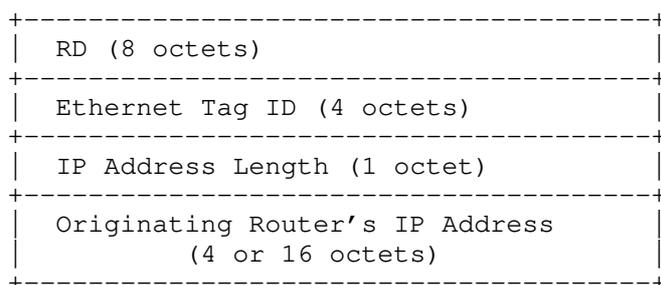
Figure 8: EVPN Route Type 3

NLRI encoding over SRv6 core is similar to what is described in
[RFC7432].

The P-Multicast Service Interface (PMSI) Tunnel Attribute [RFC6514]
is used to identify the Provider tunnel (P-tunnel) used for sending
Broadcast, Unknown Unicast, or Multicast (BUM) traffic. The format
of the PMSI Tunnel Attribute is encoded as follows over SRv6 core:

```
+---------------------------------------+
| Flag (1 octet)                        |
+---------------------------------------+
| Tunnel Type (1 octet)                 |
+---------------------------------------+
```

```
          |  MPLS label (3 octets)            |
          +------------------------------------+
          |  Tunnel Identifier (variable)     |
          +------------------------------------+
```
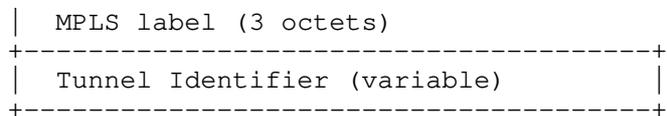
                 Figure 9: PMSI Tunnel Attribute

   Flag:
      This field has a value of 0, as defined per [RFC7432].

   Tunnel Type:
      This field is defined per [RFC6514].

   MPLS label:
      This 24-bit field carries the whole or a portion of the Function
      part of the SRv6 SID when ingress replication is used and the
      Transposition Scheme of encoding (Section 4) is used; otherwise,
      it is set as defined in [RFC6514]. When using the Transposition
      Scheme, the Transposition Length MUST be less than or equal to 24
      and less than or equal to the FL.

   Tunnel Identifier:
      This field is the IP address of egress PE.

   A Service SID enclosed in an SRv6 L2 Service TLV within the BGP
   Prefix-SID attribute is advertised along with the route. The SRv6
   Endpoint Behavior SHOULD be End.DT2M.

   * When ESI-based filtering is used for multihoming or Ethernet Tree
      (E-Tree) procedures, the ESI Filtering Argument (the Arg.FE2
      notation introduced in [RFC8986]) of the Service SID carried along
      with EVPN Route Type 1 SHOULD be merged with the applicable
      End.DT2M SID of Route Type 3 advertised by the remote PE by doing
      a bitwise logical-OR operation to create a single SID on the
      ingress PE. Details of split-horizon, ESI-based filtering
      mechanisms for multihoming are described in [RFC7432]. Details of
      filtering mechanisms for Leaf-originated BUM traffic in EVPN
      E-Tree services are provided in [RFC8317].

   * When "local-bias" is used as the multihoming split-horizon method,
      the ESI Filtering Argument SHOULD NOT be merged with the
      corresponding End.DT2M SID on the ingress PE. Details of the
      local-bias procedures are described in [RFC8365].

   Usage of multicast trees as P-tunnels is outside the scope of this
   document.

6.4. Ethernet Segment Route over SRv6 Core

   As a reminder, an Ethernet Segment route (i.e., EVPN Route Type 4) is
   encoded as follows:

              +------------------------------------+
              | RD (8 octets) |
              +------------------------------------+
              | Ethernet Tag ID (4 octets) |
              +------------------------------------+
              | IP Address Length (1 octet) |
              +------------------------------------+
              | Originating Router's IP Address |
              | (4 or 16 octets) |
              +------------------------------------+
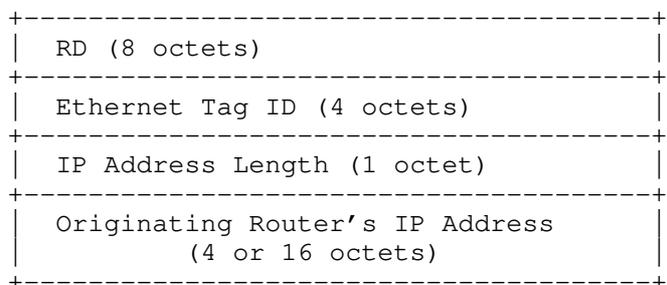
                    Figure 10: EVPN Route Type 4

   NLRI encoding over SRv6 core is similar to what is described in
   [RFC7432].

   SRv6 Service TLVs within the BGP Prefix-SID attribute are not
   advertised along with this route. The processing of the route has
   not changed -- it remains as described in [RFC7432].

6.5. IP Prefix Route over SRv6 Core

EVPN Route Type 5 is used to advertise IP address reachability
through MP-BGP to all other PEs in a given EVPN instance. The IP
address may include a host IP prefix or any specific subnet.

As a reminder, EVPN Route Type 5 is encoded as follows:

```
+-------------------------------------------+
| RD (8 octets)                             |
+-------------------------------------------+
| Ethernet Segment Identifier (10 octets)|
+-------------------------------------------+
| Ethernet Tag ID (4 octets)                |
+-------------------------------------------+
| IP Prefix Length (1 octet)                |
+-------------------------------------------+
| IP Prefix (4 or 16 octets)                |
+-------------------------------------------+
| GW IP Address (4 or 16 octets)            |
+-------------------------------------------+
| MPLS Label (3 octets)                     |
+-------------------------------------------+
```
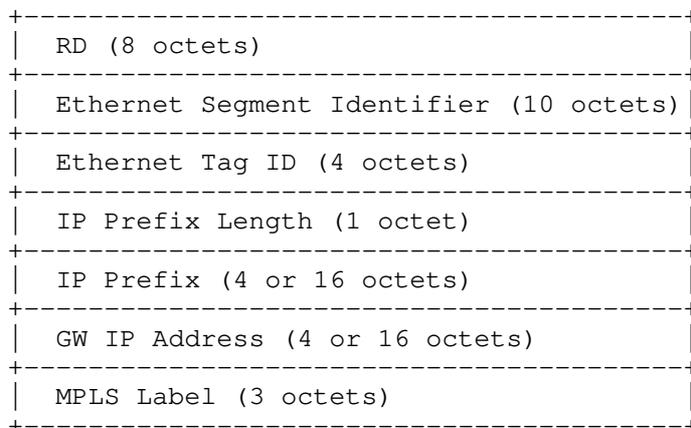
Figure 11: EVPN Route Type 5

NLRI encoding over SRv6 core is similar to what is described in
[RFC9136] with the following change:

MPLS Label:
    This 24-bit field carries the whole or a portion of the Function
    part of the SRv6 SID when the Transposition Scheme of encoding
    (Section 4) is used; otherwise, it is set to Implicit NULL in the
    higher-order 20 bits (i.e., as 0x000030). In either case, the
    value is set in the 24 bits. When using the Transposition Scheme,
    the Transposition Length MUST be less than or equal to 24 and less
    than or equal to the FL.

The SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV.
The SRv6 Endpoint Behavior SHOULD be one of these: End.DT4, End.DT6,
End.DT46, End.DX4, or End.DX6.

6.6. EVPN Multicast Routes (Route Types 6, 7, and 8) over SRv6 Core

These routes do not require the advertisement of SRv6 Service TLVs
along with them. Similar to EVPN Route Type 4, the BGP next hop is
equal to the IPv6 address of egress PE.

7. Error Handling

In case of any errors encountered while processing SRv6 Service TLVs,
the details of the error SHOULD be logged for further analysis.

If multiple instances of the SRv6 L3 Service TLV are encountered, all
but the first instance MUST be ignored.

If multiple instances of the SRv6 L2 Service TLV are encountered, all
but the first instance MUST be ignored.

An SRv6 Service TLV is considered malformed in the following cases:

* The TLV Length is less than 1.

* The TLV Length is inconsistent with the length of the BGP Prefix-
   SID attribute.

* At least one of the constituent Sub-TLVs is malformed.

An SRv6 Service Sub-TLV is considered malformed in the following
case:

* The Sub-TLV Length is inconsistent with the length of the
      enclosing SRv6 Service TLV.

   An SRv6 SID Information Sub-TLV is considered malformed in the
   following cases:

   * The Sub-TLV Length is less than 21.

   * The Sub-TLV Length is inconsistent with the length of the
      enclosing SRv6 Service TLV.

   * At least one of the constituent Sub-Sub-TLVs is malformed.

   An SRv6 Service Data Sub-Sub-TLV is considered malformed in the
   following case:

   * The Sub-Sub-TLV Length is inconsistent with the length of the
      enclosing SRv6 service Sub-TLV.

   Any TLV, Sub-TLV, or Sub-Sub-TLV is not considered malformed because
   its Type is unrecognized.

   Any TLV, Sub-TLV, or Sub-Sub-TLV is not considered malformed because
   of failing any semantic validation of its Value field.

   The SRv6 overlay service requires the Service SID for forwarding.
   The treat-as-withdraw action [RFC7606] MUST be performed when at
   least one malformed SRv6 Service TLV is present in the BGP Prefix-SID
   attribute.

   The SRv6 SID value in the SRv6 SID Information Sub-TLV is invalid
   when the SID Structure Sub-Sub-TLV transposition length is greater
   than the number of bits of the label field or if any of the
   conditions for the fields of the Sub-Sub-TLV, as specified in
   Section 3.2.1, is not met. The transposition offset and length MUST
   be 0 when the Sub-Sub-TLV is advertised along with routes where the
   Transposition Scheme is not applicable (e.g., for global IPv6 service
   [RFC2545] where there is no label field). The path having any such
   Prefix-SID attribute without any valid SRv6 SID information MUST be
   considered ineligible during the selection of the best path for the
   corresponding prefix.

8. IANA Considerations

8.1. BGP Prefix-SID TLV Types Registry

   This document introduces two new TLV Types of the BGP Prefix-SID
   attribute. IANA has assigned Type values in the "BGP Prefix-SID TLV
   Types" subregistry as follows:

              +=======+=====================+===========+
              | Value | Type | Reference |
              +=======+=====================+===========+
              | 4 | Deprecated | RFC 9252 |
              +-------+---------------------+-----------+
              | 5 | SRv6 L3 Service TLV | RFC 9252 |
              +-------+---------------------+-----------+
              | 6 | SRv6 L2 Service TLV | RFC 9252 |
              +-------+---------------------+-----------+

                    Table 1: BGP Prefix-SID TLV Types
                             Subregistry

   Value 4 previously corresponded to the SRv6-VPN SID TLV, which was
   specified in earlier draft versions of this document and used by
   early implementations of this specification. It was deprecated and
   replaced by the SRv6 L3 Service and SRv6 L2 Service TLVs.

8.2. SRv6 Service Sub-TLV Types Registry

IANA has created and now maintains a new subregistry called "SRv6
Service Sub-TLV Types" under the "Border Gateway Protocol (BGP)
Parameters" registry. The registration procedures, per [RFC8126],
for this subregistry are according to Table 2.

Range	Registration Procedures
1-127	IETF Review
128-254	First Come First Served
255	IETF Review

Table 2: SRv6 Service Sub-TLV
Types Subregistry Registration
Procedures

IANA has populated this subregistry as follows. Note that the SRv6
SID Information Sub-TLV is defined in this document:

Value	Type	Reference
0	Reserved	RFC 9252
1	SRv6 SID Information Sub-TLV	RFC 9252
255	Reserved	RFC 9252

Table 3: SRv6 Service Sub-TLV Types Subregistry
Initial Contents

8.3. SRv6 Service Data Sub-Sub-TLV Types Registry

IANA has created and now maintains a new subregistry called "SRv6
Service Data Sub-Sub-TLV Types" under the "Border Gateway Protocol
(BGP) Parameters" registry. The registration procedures for this
subregistry are according to Table 4.

Range	Registration Procedure
1-127	IETF Review
128-254	First Come First Served
255	IETF Review

Table 4: SRv6 Service Data Sub-
Sub-TLV Types Subregistry
Registration Procedures

The following Sub-Sub-TLV Type is defined in this document:

Value	Type	Reference
0	Reserved	RFC 9252
1	SRv6 SID Structure Sub-Sub-TLV	RFC 9252
255	Reserved	RFC 9252

Table 5: SRv6 Service Data Sub-Sub-TLV Types
Subregistry Initial Contents

8.4. BGP SRv6 Service SID Flags Registry

IANA has created and now maintains a new subregistry called "BGP SRv6 Service SID Flags" under the "Border Gateway Protocol (BGP) Parameters" registry. The registration procedure for this subregistry is IETF Review, and all 8-bit positions of the flags are currently unassigned.

8.5. SAFI Values Registry

IANA has added this document as a reference for value 128 ("MPLS-labeled VPN address") in the "SAFI Values" subregistry under the "Subsequent Address Family Identifiers (SAFI) Parameters" registry.

9. Security Considerations

This document specifies extensions to the BGP protocol for the signaling of services for SRv6. These specifications leverage existing BGP protocol mechanisms for the signaling of various types of services. It also builds upon existing elements of the SR architecture (more specifically, SRv6). As such, this section largely provides pointers (as a reminder) to the security considerations of those existing specifications while also covering certain, newer security aspects for the specifications newly introduced by this document.

9.1. Considerations Related to BGP Sessions

Techniques related to authentication of BGP sessions for securing messages between BGP peers, as discussed in the BGP specification [RFC4271] and in the security analysis for BGP [RFC4272], apply. The discussion of the use of the TCP Authentication Option to protect BGP sessions is found in [RFC5925], while [RFC6952] includes an analysis of BGP keying and authentication issues. This document does not introduce any additional BGP session security considerations.

9.2. Considerations Related to BGP Services

This document does not introduce new services or BGP NLRI types but extends the signaling of existing ones for SRv6. Therefore, the security considerations for the respective BGP services, such as BGP IPv4 over IPv6 NH [RFC8950], BGP IPv6 L3VPN [RFC4659], BGP IPv6 [RFC2545], BGP EVPN [RFC7432], and IP EVPN [RFC9136], apply as discussed in their respective documents. [RFC8669] discusses mechanisms to prevent the leaking of the BGP Prefix-SID attribute, which carries SR information, outside the SR domain.

As a reminder, several of the BGP services (i.e., the AFI/SAFI used for their signaling) were initially introduced for one encapsulation mechanism and later extended for others, e.g., EVPN MPLS [RFC7432] was extended for Virtual eXtensible Local Area Network (VXLAN) encapsulation and Network Virtualization Using Generic Routing Encapsulation (NVGRE) [RFC8365]. [RFC9012] enables the use of various IP encapsulation mechanisms along with different BGP SAFIs for their respective services. The existing filtering mechanisms for preventing the leak of the encapsulation information (carried in BGP attributes) and preventing the advertisement of prefixes from the provider's internal address space (especially the SRv6 Block, as discussed in [RFC8986]) to external peers (or into the Internet) also apply in the case of SRv6.

Specific to SRv6, a misconfiguration or error in the BGP filtering mechanisms mentioned above may result in exposing information, such as SRv6 Service SIDs to external peers or other unauthorized entities. However, an attempt to exploit this information or to raise an attack by injecting packets into the network (e.g., customer networks in case of VPN services) is mitigated by the existing SRv6 data plane security mechanisms, as described in the next section.

9.3. Considerations Related to SR over IPv6 Data Plane

This section provides a brief reminder and an overview of the
security considerations related to SRv6 with pointers to existing
specifications. This document introduces no new security
considerations of its own from the SRv6 data plane perspective.

SRv6 operates within a trusted SR domain. The data packets
corresponding to service flows between PE routers are encapsulated
(using SRv6 SIDs advertised via BGP) and carried within this trusted
SR domain (e.g., within a single AS or between multiple ASes within a
single provider network).

The security considerations of the SR architecture are covered by
[RFC8402]. More detailed security considerations, specifically of
SRv6 and SRH, are covered by [RFC8754] as they relate to SR Attacks
(Section 7.1), Service Theft (Section 7.2), and Topology Disclosure
(Section 7.3). As such, an operator deploying SRv6 MUST follow the
considerations described in Section 7 of [RFC8754] to implement the
infrastructure Access Control Lists (ACLs) and the recommendations
described in BCP 38 [RFC2827] and BCP 84 [RFC3704].

The SRv6 deployment and SID allocation guidelines, as described in
[RFC8986], simplify the deployment of the ACL filters (e.g., a single
ACL corresponding to the SRv6 Block applied to the external
interfaces on border nodes is sufficient to block packets destined to
any SRv6 SID in the domain from external/unauthorized networks).
While there is an assumed trust model within an SR domain, such that
any node sending a packet to an SRv6 SID is assumed to be allowed to
do so, there is also the option of using an SRH Hashed Message
Authentication Code (HMAC) TLV [RFC8754], as described in [RFC8986],
for validation.

The SRv6 Endpoint Behaviors implementing the services signaled in
this document are defined in [RFC8986]; hence, the security
considerations of that document apply. These considerations are
independent of the protocol used for service deployment, i.e.,
independent of BGP signaling of SRv6 services.

These considerations help protect transit traffic as well as
services, such as VPNs, to avoid service theft or injection of
traffic into customer VPNs.

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