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SRv6 BGP based Overlay services
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Abstract

   This draft defines procedures and messages for SRv6-based BGP
   services including L3VPN, EVPN and Internet services. It builds on
   RFC4364 "BGP/MPLS IP Virtual Private Networks (VPNs)" and RFC7432
   "BGP MPLS-Based Ethernet VPN".

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1. Introduction

   SRv6 refers to Segment Routing [RFC8402] instantiated on the IPv6
   dataplane [RFC8754].

   SRv6 based BGP services refers to the L3 and L2 overlay services with
   BGP as control plane and SRv6 as dataplane.

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

   SRv6 Service SID refers to an SRv6 SID associated with one of the
   service specific behavior on the advertising Provider Edge (PE)
   router, such as (but not limited to), END.DT (Table lookup in a VRF)
   or END.DX (cross-connect to a nexthop) behaviors in the case of L3VPN
   service as defined in [I-D.ietf-spring-srv6-network-programming].

   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 need to support plain IPv6
   forwarding [RFC8200].

   To provide SRv6 service in conjunction with an underlay SLA from the
   ingress PE to the egress PE, the egress PE colors the overlay service
   route with a Color extended community
   [I-D.ietf-idr-segment-routing-te-policy]. The ingress PE
   encapsulates the payload packet in an outer IPv6 header with the
   segment list of SR policy associated with the related SLA followed by
   the SRv6 Service SID associated with the route. The underlay nodes
   whose SRv6 SID's are part of the segment list MUST support SRv6 data
   plane.

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

   This document describes how existing BGP messages between PEs may
   carry SRv6 Service SIDs as a means to interconnect PEs and form VPNs.

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 BGP Prefix-SID attribute [RFC8669] to carry
SRv6 SIDs and associated information.

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.

o   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. Some behaviors which MAY be encoded, but not
    limited to, are End.DX4, End.DT4, End.DX6, End.DT6, etc.

o   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 Label1 for EVPN Route-Types as
    defined in[RFC7432]. Some behaviors which MAY be encoded, but not
    limited to, are End.DX2, End.DX2V, End.DT2U, End.DT2M etc.

When an egress PE is enabled for BGP Services over SRv6 data-plane,
it MUST signal one or more SRv6 Service SIDs enclosed in SRv6 Service
TLV(s) within the BGP Prefix-SID Attribute attached to MP-BGP NLRIs
defined in [RFC4760] [RFC4659] [I-D.ietf-bess-rfc5549revision]
[RFC7432] [RFC4364] where applicable as described in Section 5 and
Section 6.

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                                     //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

o   TLV Type (1 octet): This field is assigned values from the IANA
    registry "BGP Prefix-SID TLV Types". It is set to 5 for SRv6 L3
    Service TLV. It is set to 6 for SRv6 L2 Service TLV.

o   TLV Length (2 octets): Specifies the total length of the TLV
    Value.

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

o   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 BGP Prefix-SID Attribute
with one or more SRv6 Service TLVs observes the following rules when
advertising the received route to other peers:

o   if the nexthop is unchanged during 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 or Sub-TLV or Sub-Sub-TLV MUST be propagated unchanged.

o   if the nexthop is changed, the TLVs, Sub-TLVs and Sub-Sub-TLVs
    SHOULD be updated as appropriate. Any unrecognized received sub-
    TLVs and Sub-Sub-TLVs 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        //
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

o   SRv6 Service Sub-TLV Type (1 octet): Identifies the type of SRv6
    service information. It is assigned values from the IANA Registry
    "SRv6 Service Sub-TLV Types".

o   SRv6 Service Sub-TLV Length (2 octets): Specifies the total length
    of the Sub-TLV Value field.

o   SRv6 Service Sub-TLV Value (variable): 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 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 bytes)                                  //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| SRv6 SID Flags|  SRv6 Endpoint Behavior        |  RESERVED2   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//  SRv6 Service Data Sub-Sub-TLVs                             //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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

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

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

o SRv6 SID Value (16 octets): Encodes an SRv6 SID as defined in
   [I-D.ietf-spring-srv6-network-programming]

o SRv6 SID Flags (1 octet): Encodes SRv6 SID Flags - none are
   currently defined. SHOULD be set to 0 by sender and MUST be
   ignored by the receiver.

o SRv6 Endpoint Behavior (2 octets): Encodes SRv6 Endpoint behavior
   codepoint value from the IANA registry defined in section 9.2 of
   [I-D.ietf-spring-srv6-network-programming] that is associated with
   SRv6 SID. The opaque behavior (i.e. value 0xFFFF) or an
   unrecognized behavior MUST NOT be considered as invalid by the
   receiver.

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

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

   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         |                                 |          //
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   o SRv6 Service Data Sub-Sub-TLV Type (1 octet): Identifies the type
      of Sub-Sub-TLV. It is assigned values from the IANA Registry
      "SRv6 Service Data Sub-Sub-TLVs".

   o SRv6 Service Data Sub-Sub-TLV Length (2 octets): Specifies the
      total length of the Sub-Sub-TLV Value field.

   o SRv6 Service Data Sub-Sub-TLV Value (variable): 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 SRv6 SID
   structure Sub-Sub-TLV. SRv6 SID Structure Sub-Sub-TLV is used to
   advertise the lengths of each individual parts of the SRv6 SID as
   defined in [I-D.ietf-spring-srv6-network-programming]. It is carried
   as Sub-Sub-TLV in 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=6                    |               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     | Locator Node  | Function      | Argument      | Transposition |
     | Length        | Length        | Length        | Length        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     | Transposition |
     | Offset        |
     +-+-+-+-+-+-+-+-+
```

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

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

   o Locator Block Length (1 octet): Contains length of SRv6 SID
      locator Block in bits.

   o Locator Node Length (1 octet): Contains length of SRv6 SID locator
      Node in bits.

   o Function Length (1 octet): Contains length of SRv6 SID Function in
      bits.

   o Argument Length (1 octet): Contains length of SRv6 SID argument in
      bits.

   o Transposition Length (1 octet): Size in bits for the part of SID
      that has been transposed (or shifted) into a label field

   o Transposition Offset (1 octet): The offset position in bits for
      the part of SID that has been transposed (or shifted) into a label
      field.

   Section 4 describes mechanisms for signaling of the SRv6 Service SID
   by transposing a variable part of the SRv6 SID value (function and/or
   the argument parts) and carrying them in existing 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 put into high order bits of label field. The bits
that have been shifted out MUST be set to 0 in the SID value.

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.

Since size of label field is 24 bits, only that many bits can be
transposed from the SRv6 SID value into it.

As an example, when the entire function part of size 16 of an SRv6
SID is transposed and the sum of the locator block and locator node
parts is 64, then the transposition offset would be set to 64 and the
transposition length is set to 16.

BGP speakers that do not support this specification may misinterpret,
on reception of an SRv6-based BGP service route update, the function
and/or argument parts of the SRv6 SID encoded in label field(s) as
MPLS label values for MPLS-based services. Implementations
supporting this specification SHOULD provide a mechanism to control
advertisement of SRv6-based BGP service routes on a per neighbor and
per service basis.

Arguments MAY be generally applicable for SIDs of only specific
behaviors (e.g. End.DT2M) and therefore the argument length MUST be
set to 0 for SIDs where the argument is not applicable.

4. Encoding SRv6 SID information

The SRv6 Service SID(s) for a BGP Service Prefix are 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 VPWS where
a per-PW SID allocation is required (i.e. End.DX2 behavior), each
NLRI would have its own unique SID there by resulting in inefficient
packing.

To achieve efficient packing, this document allows the encoding of
the SRv6 Service SID either as a whole in the SRv6 Services TLVs or
the encoding of only the common part of the SRv6 SID (e.g. Locator)
in the SRv6 Services TLVs and encoding the variable (e.g. Function
and 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 to also indicate
offset of variable part along with its length in SRv6 SID value. The
use of the Transposition Scheme is RECOMMENDED for the specific
service encodings that allow it as described further in Section 5 and
Section 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 label field.

In yet another example, for the EVPN Per-ES A-D 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 ESI Label field of the ESI Label Extended Community and the SID
value in the SRv6 Services TLV is set to 0 with 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 argument part SID value moved to
label field is set in transposition offset and length of 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 Per-ES A-D route
into the correct transposition offset and length in the SRv6 SID with
the End.DT2M behavior received for a 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 which supports SRv6 based L3 services advertises overlay
service prefixes along with a Service SID enclosed in a 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 choose to
perform IPv6 encapsulation and optionally insert an SRH [RFC8754]
when required; second ,it indicates the value of the Service SID to
be used in the encapsulation.

The Service SID thus signaled only has local significance at the
egress PE, where it may be allocated or configured on a per-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 [I-D.ietf-spring-srv6-network-programming].

The SRv6 Service SID SHOULD be routable within the AS of the egress
PE and serves the dual purpose of providing reachability between
ingress PE and egress PE while also encoding the endpoint behavior.

When the egress PE sets the next-hop to a value that is not covered
by the SRv6 Locator from which the SRv6 Service SID is allocated,
then the ingress PE SHOULD perform reachability check for the SRv6
Service SID in addition to the BGP next-hop reachability procedures.

At an ingress PE, BGP installs the received prefix in the correct RIB
table, recursing via an SR Policy leveraging the received SRv6
Service SID.

Assuming best-effort connectivity to the egress PE, the ingress PE
encapsulates the payload in an outer IPv6 header where the
destination address is the SRv6 Service SID associated with the
related BGP route update.

However, when the received route is colored with an extended color
community 'C' and Next-Hop 'N', and the ingress PE has a valid SRv6
Policy (C, N) associated with SID list <S1,S2, S3>
[I-D.ietf-spring-segment-routing-policy], then the effective SR
Policy is <S1, S2, S3-Service-SID>.

Multiple VPN routes MAY resolve recursively via the same SR Policy.

5.1. IPv4 VPN Over SRv6 Core

The MP_REACH_NLRI for SRv6 core is encoded according to IPv4 VPN Over
IPv6 Core defined in [I-D.ietf-bess-rfc5549revision].

Label field of IPv4-VPN NLRI is encoded as specified in [RFC8277]
with the Label Value set to the Function part of the SRv6 SID when
the Transposition Scheme of encoding (Section 4) is used and
otherwise set to Implicit NULL.

SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV. The
behavior of the SRv6 SID is entirely up to the originator of the
advertisement. In practice, the behavior is End.DX4 or End.DT4.

5.2. IPv6 VPN Over SRv6 Core

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

   Label field of the IPv6-VPN NLRI is encoded as specified in [RFC8277]
   with the Label Value set to the Function part of the SRv6 SID when
   the Transposition Scheme of encoding (Section 4) is used and
   otherwise set to Implicit NULL.

   SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV. The
   behavior of the SRv6 SID is entirely up to the originator of the
   advertisement. In practice, the behavior is End.DX6 or End.DT6.

5.3. Global IPv4 over SRv6 Core

   The MP_REACH_NLRI for SRv6 core is encoded according to IPv4 over
   IPv6 Core is defined in [I-D.ietf-bess-rfc5549revision].

   SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV. The
   behavior of the SRv6 SID is entirely up to the originator of the
   advertisement. In practice, the behavior is End.DX4 or End.DT4.

5.4. Global IPv6 over SRv6 Core

   The MP_REACH_NLRI for SRv6 core is encoded according to [RFC2545]

   SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV. The
   behavior of the SRv6 SID is entirely up to the originator of the
   advertisement. In practice, the behavior is End.DX6 or End.DT6.

6. BGP based Ethernet VPN (EVPN) over SRv6

   [RFC7432] provides an extendable method of building an Ethernet VPN
   (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 specific use for MPLS encapsulation of EVPN
   traffic. Route Type 5 carrying MPLS label information (and thus
   encapsulation information) for EVPN is defined in
   [I-D.ietf-bess-evpn-prefix-advertisement]. Route Types 6,7 and 8 are
   defined in [I-D.ietf-bess-evpn-igmp-mld-proxy].

   o Ethernet Auto-discovery Route (Route Type 1)

   o MAC/IP Advertisement Route (Route Type 2)

   o Inclusive Multicast Ethernet Tag Route (Route Type 3)

o Ethernet Segment route (Route Type 4)

o IP prefix route (Route Type 5)

o Selective Multicast Ethernet Tag route (Route Type 6)

o IGMP join sync route (Route Type 7)

o IGMP leave sync route (Route Type 8)

To support SRv6 based EVPN overlays, one or more SRv6 Service SIDs
are advertised with Route Type 1,2,3 and 5. The SRv6 Service SID(s)
per Route Type are advertised in SRv6 L3/L2 Service TLVs within the
BGP Prefix-SID Attribute. Signaling of 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 optionally 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 within the AS of the egress
PE and serves the dual purpose of providing reachability between
ingress PE and egress PE while also encoding the endpoint behavior.

When the egress PE sets the next-hop to a value that is not covered
by the SRv6 Locator from which the SRv6 Service SID is allocated,
then the ingress PE SHOULD perform reachability check for the SRv6
Service SID in addition to the BGP next-hop reachability procedures.

6.1. Ethernet Auto-discovery route over SRv6 Core

Ethernet Auto-Discovery (A-D) routes are Route Type 1 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 used to
advertise point-to-point services ID.

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)               |
            +--------------------------------------+
```

6.1.1. Per-ES A-D route

Per-ES A-D route for SRv6 overlay is advertised as follows:

o BGP next-hop: IPv6 address of an egress PE

o Ethernet Tag ID: set as per [RFC7432]

o MPLS Label: set as per [RFC7432]

o ESI label extended community ESI label field: carries the Argument
   part of the SRv6 SID when ESI filtering approach is used along
   with the Transposition Scheme of encoding (Section 4) and
   otherwise set to Implicit NULL.

A Service SID enclosed in a SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the A-D route. The
behavior of the Service SID thus signaled is entirely up to the
originator of the advertisement. When ESI filtering approach is
used, the Service SID is used to signal Arg.FE2 SID argument for
applicable End.DT2M SIDs. When local-bias approach is used, the
Service SID MAY be of value 0.

6.1.2. Per-EVI A-D route

Per-EVI A-D route for SRv6 overlay is advertised as follows:

o BGP next-hop: IPv6 address of an egress PE

o Ethernet Tag ID: Set as per [RFC7432], [RFC8214] and
   [I-D.ietf-bess-evpn-vpws-fxc]

o MPLS Label: carries the Function part of the SRv6 SID when the
   Transposition Scheme of encoding (Section 4) is used and otherwise
   set to Implicit NULL.

A Service SID enclosed in a SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the A-D route. The
behavior of the Service SID thus signaled is entirely up to the
originator of the advertisement. In practice, the behavior is
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 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)           |
            +----------------------------------------+
```

o BGP next-hop: IPv6 address of an egress PE

o MPLS Label1: Is associated with the SRv6 L2 Service TLV. It
   carries the Function part of the SRv6 SID when the Transposition
   Scheme of encoding (Section 4) is used and otherwise set to
   Implicit NULL.

o MPLS Label2: Is associated with the SRv6 L3 Service TLV. It
   carries the Function part of the SRv6 SID when the Transposition
   Scheme of encoding (Section 4) is used and otherwise set to
   Implicit NULL.

Service SIDs enclosed in SRv6 L2 Service TLV and optionally in SRv6
L3 Service TLV within the BGP Prefix-SID attribute is 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

o MPLS Label1: Is associated with the SRv6 L2 Service TLV. It
   carries the Function part of the SRv6 SID when the Transposition
   Scheme of encoding (Section 4) is used and otherwise set to
   Implicit NULL.

A Service SID enclosed in a SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the route. The
behavior of the Service SID thus signaled is entirely up to the
originator of the advertisement. In practice, the behavior is
END.DX2 or END.DT2U.

6.2.2. MAC/IP Advertisement route with MAC+IP

o MPLS Label1: Is associated with the SRv6 L2 Service TLV. It
   carries the Function part of the SRv6 SID when the Transposition
   Scheme of encoding (Section 4) is used and otherwise set to
   Implicit NULL.

o MPLS Label2: Is associated with the SRv6 L3 Service TLV. It
   carries the Function part of the SRv6 SID when the Transposition
   Scheme of encoding (Section 4) is used and otherwise set to
   Implicit NULL.

An L2 Service SID enclosed in a SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the route. In
addition, an L3 Service SID enclosed in a SRv6 L3 Service TLV within
the BGP Prefix-SID attribute MAY also be advertised along with the
route. The behavior of the Service SID(s) thus signaled is entirely
up to the originator of the advertisement. In practice, the behavior
is END.DX2 or END.DT2U for the L2 Service SID, and END.DT6/4 or
END.DX6/4 for the L3 Service SID.

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)             |
                +---------------------------------------+
```

o BGP next-hop: IPv6 address of egress PE

PMSI Tunnel Attribute [RFC6514] is used to identify the P-tunnel used
for sending BUM traffic. The format of PMSI Tunnel Attribute is
encoded as follows for SRv6 Core:

```
              +---------------------------------------+
              |  Flag (1 octet)                       |
              +---------------------------------------+
              |  Tunnel Type (1 octet)                |
              +---------------------------------------+
              |  MPLS label (3 octet)                 |
              +---------------------------------------+
              |  Tunnel Identifier (variable)         |
              +---------------------------------------+
```

o Flag: zero value defined per [RFC7432]

o Tunnel Type: defined per [RFC6514]

o MPLS label: It carries the Function part of the SRv6 SID when
   ingress replication is used and the Transposition Scheme of
   encoding (Section 4) is used and otherwise it is set as defined in
   [RFC6514]

o Tunnel Identifier: IP address of egress PE

A Service SID enclosed in a SRv6 L2 Service TLV within the BGP
Prefix-SID attribute is advertised along with the route. The
behavior of the Service SID thus signaled, is entirely up to the
originator of the advertisement. In practice, the behavior of the
SRv6 SID is as follows:

o END.DT2M behavior.

o When ESI-based filtering is used for Multi-Homing or E-Tree
   procedures, the ESI Filtering argument (Arg.FE2) of the Service
   SID carried along with EVPN Route Type 1 route SHOULD be merged
   together with the applicable End.DT2M SID of Type 3 route
   advertised by 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].

o When "local-bias" is used as the Multi-Homing 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].

The setup of multicast trees for use 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)             |
                +---------------------------------------+
```

o BGP next-hop: IPv6 address of egress PE

SRv6 Service TLVs within 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. IP address
may include 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)                |
                +---------------------------------------+
```

o   BGP next-hop: IPv6 address of egress PE

o   MPLS Label: It carries the Function part of the SRv6 SID when the
    Transposition Scheme of encoding (Section 4) is used and otherwise
    set to Implicit NULL.

SRv6 Service SID is encoded as part of the SRv6 L3 Service TLV. The
function of the SRv6 SID is entirely up to the originator of the
advertisement. In practice, the behavior is End.DT4/6 or End.DX4/6.

6.6. EVPN multicast routes (Route Types 6, 7, 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 Nexthop is
equal to the IPv6 address of egress PE.

7. Implementation Status

The [I-D.matsushima-spring-srv6-deployment-status] describes the
current deployment and implementation status of SRv6 which also
includes the BGP services over SRv6 as specified in this document.

8. 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 SRv6 L3 Service TLV is encountered, all but
the first instance MUST be ignored.

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

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

o   the TLV Length is less than 1

o   the TLV Length is inconsistent with the length of BGP Prefix-SID
    attribute

o   at least one of the constituent Sub-TLVs is malformed

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

o   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 cases:

o the Sub-Sub-TLV Length is inconsistent with the length of the
   enclosing SRv6 service Sub-TLV

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

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

SRv6 overlay service requires 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.

SRv6 SID value in SRv6 Service Sub-TLV is invalid when SID Structure
Sub-Sub-TLV transposition length is greater than 24 or addition of
transposition offset and length is greater than 128. Path having
such Prefix-SID Attribute should be ineligible during the selection
of best path for the corresponding prefix.

9. IANA Considerations

9.1. BGP Prefix-SID TLV Types registry

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

```
    Value     Type                     Reference
    --------------------------------------------
    4         Deprecated           <this document>
    5         SRv6 L3 Service TLV  <this document>
    6         SRv6 L2 Service TLV  <this document>
```

The value 4 previously corresponded to the SRv6-VPN SID TLV, which
was specified in previous 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.

9.2. SRv6 Service Sub-TLV Types registry

IANA is requested to create and maintain a new registry called "SRv6
Service Sub-TLV Types". The allocation policy for this registry is:

    0 : Reserved
    1-127 : IETF Review
    128-254 : First Come First Served
    255 : Reserved

The following Sub-TLV Types are defined in this document:

    Value   Type   Reference
     ----
      1   SRv6 SID Information Sub-TLV   <this document>

9.3. SRv6 Service Data Sub-Sub-TLV Types registry

IANA is requested to create and maintain a new registry called "SRv6
Service Data Sub-Sub-TLV Types". The allocation policy for this
registry is:

    0 : Reserved
    1-127 : IETF Review
    128-254 : First Come First Served
    255 : Reserved

The following Sub-Sub-TLV Types are defined in this document:

    Value   Type   Reference
     ----
      1   SRv6 SID Structure Sub-Sub-TLV   <this document>

10. Security Considerations

This document specifies extensions to BGP protocol for signalling of
services for SRv6. As such, 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 new services or BGP NLRI types but
extends the signaling of existing ones for SRv6. Therefore, the
security considerations for the respective BGP services
[I-D.ietf-bess-rfc5549revision] [RFC4659] [RFC2545] [RFC7432]
[I-D.ietf-bess-evpn-prefix-advertisement] also apply.

SRv6 operates within a trusted SR domain with filtering of traffic at
the domain boundaries. These and other security aspects of SRv6 are
discussed in the security considerations of [RFC8402] [RFC8754] and
apply for deployment of BGP services using SRv6. The SRv6 SIDs used
for the BGP Services in this document are defined in
[I-D.ietf-spring-srv6-network-programming] and hence the security
considerations of that document also apply. The service flows
between PE routers using SRv6 SIDs advertised via BGP are expected to
be limited within the trusted SR domain (e.g. within a single AS or
between multiple ASes within a single provider network). Therefore,
precaution is necessary to ensure that the BGP service information
(including associated SRv6 SID) advertised via BGP sessions is
limited to peers within this trusted SR domain. Security
consideration section of [RFC8669] discuss mechanisms to prevent
leaking of BGP Prefix-SID attribute, that carries SRv6 SID, outside
the SR domain. In the event that these filtering mechanisms, both in
the forwarding and control plane, are not implemented properly, it
may be possible for nodes outside the SR domain to learn the VPN
Service SIDs and use them to direct traffic into VPN networks from
outside the SR domain.

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13. References

13.1. Normative References

[I-D.ietf-bess-evpn-igmp-mld-proxy]
          Sajassi, A., Thoria, S., Patel, K., Drake, J., and W. Lin,
          "IGMP and MLD Proxy for EVPN", draft-ietf-bess-evpn-igmp-
          mld-proxy-05 (work in progress), April 2020.

[I-D.ietf-bess-evpn-prefix-advertisement]
          Rabadan, J., Henderickx, W., Drake, J., Lin, W., and A.
          Sajassi, "IP Prefix Advertisement in EVPN", draft-ietf-
          bess-evpn-prefix-advertisement-11 (work in progress), May
          2018.

[I-D.ietf-bess-evpn-vpws-fxc]
          Sajassi, A., Brissette, P., Uttaro, J., Drake, J., Lin,
          W., Boutros, S., and J. Rabadan, "EVPN VPWS Flexible
          Cross-Connect Service", draft-ietf-bess-evpn-vpws-fxc-01
          (work in progress), June 2019.

[I-D.ietf-bess-rfc5549revision]
          Litkowski, S., Agrawal, S., ananthamurthy, k., and K.
          Patel, "Advertising IPv4 Network Layer Reachability
          Information with an IPv6 Next Hop", draft-ietf-bess-
          rfc5549revision-04 (work in progress), July 2020.

[I-D.ietf-spring-srv6-network-programming]
          Filsfils, C., Camarillo, P., Leddy, J., Voyer, D.,
          Matsushima, S., and Z. Li, "SRv6 Network Programming",
          draft-ietf-spring-srv6-network-programming-16 (work in
          progress), June 2020.

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119,
              DOI 10.17487/RFC2119, March 1997,
              <https://www.rfc-editor.org/info/rfc2119>.

   [RFC2545] Marques, P. and F. Dupont, "Use of BGP-4 Multiprotocol
              Extensions for IPv6 Inter-Domain Routing", RFC 2545,
              DOI 10.17487/RFC2545, March 1999,
              <https://www.rfc-editor.org/info/rfc2545>.

   [RFC4271] Rekhter, Y., Ed., Li, T., Ed., and S. Hares, Ed., "A
              Border Gateway Protocol 4 (BGP-4)", RFC 4271,
              DOI 10.17487/RFC4271, January 2006,
              <https://www.rfc-editor.org/info/rfc4271>.

   [RFC4364] Rosen, E. and Y. Rekhter, "BGP/MPLS IP Virtual Private
              Networks (VPNs)", RFC 4364, DOI 10.17487/RFC4364, February
              2006, <https://www.rfc-editor.org/info/rfc4364>.

   [RFC4456] Bates, T., Chen, E., and R. Chandra, "BGP Route
              Reflection: An Alternative to Full Mesh Internal BGP
              (IBGP)", RFC 4456, DOI 10.17487/RFC4456, April 2006,
              <https://www.rfc-editor.org/info/rfc4456>.

   [RFC4659] De Clercq, J., Ooms, D., Carugi, M., and F. Le Faucheur,
              "BGP-MPLS IP Virtual Private Network (VPN) Extension for
              IPv6 VPN", RFC 4659, DOI 10.17487/RFC4659, September 2006,
              <https://www.rfc-editor.org/info/rfc4659>.

   [RFC4760] Bates, T., Chandra, R., Katz, D., and Y. Rekhter,
              "Multiprotocol Extensions for BGP-4", RFC 4760,
              DOI 10.17487/RFC4760, January 2007,
              <https://www.rfc-editor.org/info/rfc4760>.

   [RFC6514] Aggarwal, R., Rosen, E., Morin, T., and Y. Rekhter, "BGP
              Encodings and Procedures for Multicast in MPLS/BGP IP
              VPNs", RFC 6514, DOI 10.17487/RFC6514, February 2012,
              <https://www.rfc-editor.org/info/rfc6514>.

   [RFC7432] Sajassi, A., Ed., Aggarwal, R., Bitar, N., Isaac, A.,
              Uttaro, J., Drake, J., and W. Henderickx, "BGP MPLS-Based
              Ethernet VPN", RFC 7432, DOI 10.17487/RFC7432, February
              2015, <https://www.rfc-editor.org/info/rfc7432>.

   [RFC7606] Chen, E., Ed., Scudder, J., Ed., Mohapatra, P., and K.
              Patel, "Revised Error Handling for BGP UPDATE Messages",
              RFC 7606, DOI 10.17487/RFC7606, August 2015,
              <https://www.rfc-editor.org/info/rfc7606>.

   [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC
              2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174,
              May 2017, <https://www.rfc-editor.org/info/rfc8174>.

   [RFC8200] Deering, S. and R. Hinden, "Internet Protocol, Version 6
              (IPv6) Specification", STD 86, RFC 8200,
              DOI 10.17487/RFC8200, July 2017,
              <https://www.rfc-editor.org/info/rfc8200>.

   [RFC8214] Boutros, S., Sajassi, A., Salam, S., Drake, J., and J.
              Rabadan, "Virtual Private Wire Service Support in Ethernet
              VPN", RFC 8214, DOI 10.17487/RFC8214, August 2017,
              <https://www.rfc-editor.org/info/rfc8214>.

   [RFC8277] Rosen, E., "Using BGP to Bind MPLS Labels to Address
              Prefixes", RFC 8277, DOI 10.17487/RFC8277, October 2017,
              <https://www.rfc-editor.org/info/rfc8277>.

   [RFC8317] Sajassi, A., Ed., Salam, S., Drake, J., Uttaro, J.,
              Boutros, S., and J. Rabadan, "Ethernet-Tree (E-Tree)
              Support in Ethernet VPN (EVPN) and Provider Backbone
              Bridging EVPN (PBB-EVPN)", RFC 8317, DOI 10.17487/RFC8317,
              January 2018, <https://www.rfc-editor.org/info/rfc8317>.

   [RFC8365] Sajassi, A., Ed., Drake, J., Ed., Bitar, N., Shekhar, R.,
              Uttaro, J., and W. Henderickx, "A Network Virtualization
              Overlay Solution Using Ethernet VPN (EVPN)", RFC 8365,
              DOI 10.17487/RFC8365, March 2018,
              <https://www.rfc-editor.org/info/rfc8365>.

   [RFC8402] Filsfils, C., Ed., Previdi, S., Ed., Ginsberg, L.,
              Decraene, B., Litkowski, S., and R. Shakir, "Segment
              Routing Architecture", RFC 8402, DOI 10.17487/RFC8402,
              July 2018, <https://www.rfc-editor.org/info/rfc8402>.

   [RFC8669] Previdi, S., Filsfils, C., Lindem, A., Ed., Sreekantiah,
              A., and H. Gredler, "Segment Routing Prefix Segment
              Identifier Extensions for BGP", RFC 8669,
              DOI 10.17487/RFC8669, December 2019,
              <https://www.rfc-editor.org/info/rfc8669>.

   [RFC8754] Filsfils, C., Ed., Dukes, D., Ed., Previdi, S., Leddy, J.,
              Matsushima, S., and D. Voyer, "IPv6 Segment Routing Header
              (SRH)", RFC 8754, DOI 10.17487/RFC8754, March 2020,
              <https://www.rfc-editor.org/info/rfc8754>.

13.2. **Informative References**

   [I-D.ietf-idr-segment-routing-te-policy]
              Previdi, S., Filsfils, C., Talaulikar, K., Mattes, P.,
              Rosen, E., Jain, D., and S. Lin, "Advertising Segment
              Routing Policies in BGP", draft-ietf-idr-segment-routing-
              te-policy-09 (work in progress), May 2020.

   [I-D.ietf-spring-segment-routing-policy]
              Filsfils, C., Talaulikar, K., Voyer, D., Bogdanov, A., and
              P. Mattes, "Segment Routing Policy Architecture", draft-
              ietf-spring-segment-routing-policy-08 (work in progress),
              July 2020.

   [I-D.matsushima-spring-srv6-deployment-status]
              Matsushima, S., Filsfils, C., Ali, Z., Li, Z., and K.
              Rajaraman, "SRv6 Implementation and Deployment Status",
              draft-matsushima-spring-srv6-deployment-status-07 (work in
              progress), April 2020.

   [RFC4272] Murphy, S., "BGP Security Vulnerabilities Analysis",
              RFC 4272, DOI 10.17487/RFC4272, January 2006,
              <https://www.rfc-editor.org/info/rfc4272>.

   [RFC5925] Touch, J., Mankin, A., and R. Bonica, "The TCP
              Authentication Option", RFC 5925, DOI 10.17487/RFC5925,
              June 2010, <https://www.rfc-editor.org/info/rfc5925>.

   [RFC6952] Jethanandani, M., Patel, K., and L. Zheng, "Analysis of
              BGP, LDP, PCEP, and MSDP Issues According to the Keying
              and Authentication for Routing Protocols (KARP) Design
              Guide", RFC 6952, DOI 10.17487/RFC6952, May 2013,
              <https://www.rfc-editor.org/info/rfc6952>.

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