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Authors:	K. Talaulikar	K. Raza	J. Rabadan	W. Lin
	<i>Cisco Systems</i>	<i>Cisco Systems</i>	<i>Nokia</i>	<i>Juniper Networks</i>

RFC 9819

Argument Signaling for BGP Services in Segment Routing over IPv6 (SRv6)

Abstract

RFC 9252 defines procedures and messages for BGP overlay services for Segment Routing over IPv6 (SRv6), including Layer 3 Virtual Private Network (L3VPN), Ethernet VPN (EVPN), and global Internet routing. This document updates RFC 9252 and provides more detailed specifications for the signaling and processing of SRv6 Segment Identifier advertisements for BGP overlay service routes associated with SRv6 Endpoint Behaviors that support arguments.

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1. Introduction

SRv6 refers to Segment Routing instantiated over the IPv6 data plane [RFC8402]. An SRv6 Segment Identifier (SID) [RFC8402] can be associated with one of the service-specific SRv6 Endpoint Behaviors on the advertising Provider Edge (PE) router for Layer 3 Virtual Private Network (L3VPN), global Internet routing, and Ethernet VPN (EVPN) services as defined in [RFC8986]. Such SRv6 SIDs are referred to as SRv6 Service SIDs. [RFC9252] defines the procedures and messages for the signaling of BGP overlay services including L3VPN, EVPN, and Internet services using SRv6.

For certain EVPN services, Section 4.12 of [RFC8986] introduced the End.DT2M SRv6 Endpoint Behavior, which utilizes arguments (i.e., Arg.FE2). [RFC9252] subsequently specified the encoding and signaling procedures for the SRv6 SID and its associated argument via EVPN Route

Type 3 and EVPN Route Type 1, respectively. However, during implementation and interoperability testing, it was observed that the specifications outlined in [RFC9252] lack sufficient detail, leading to ambiguities in interpretation and implementation.

This document updates [RFC9252] by providing additional details and clarifications regarding the signaling of SRv6 Service SIDs associated with SRv6 Endpoint Behaviors that utilize arguments. While the focus is primarily on the signaling of the End.DT2M SRv6 Endpoint Behavior via EVPN Route Types 1 and 3, the procedures described herein are also applicable to other similar SRv6 Endpoint Behaviors with arguments that may be signaled using BGP.

Section 6.3 of [RFC9252] specifies that the SRv6 Service SID used in the data plane is derived by applying a bitwise logical-OR operation between the SID with an argument signaled via EVPN Route Type 1 and the SID with the 'Locator + Function' components signaled via EVPN Route Type 3. However, this approach assumes a uniform SID structure across all SIDs advertised via EVPN Route Types 1 and 3. This assumption is not universally valid, and the procedures in this document remove this restriction, ensuring greater flexibility in SRv6 SID signaling.

The descriptions and examples presented in this document do not utilize the Transposition Scheme (see Section 4 of [RFC9252]). Consequently, the Transposition Offset (TPOS-O) and Transposition Length (TPOS-L) are set to zero, and references to MPLS label fields where the function or argument portions may be transposed are omitted. However, the same examples could be applied with the Transposition Scheme. This document does not introduce any modifications to the use of the Transposition Scheme in the signaling of EVPN routes. Implementations are expected to adhere to the procedures and recommendations specified in [RFC9252] concerning the Transposition Scheme.

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. Advertisement of SRv6 SID and Arguments

Section 3.1 of [RFC8986] defines the format of an SRv6 SID as consisting of three components: Locator (LOC), Function (FUNC), and Argument (ARG). For SRv6 SIDs associated with SRv6 Endpoint Behaviors that do not support arguments, the ARG component is not present. Consequently, all bits following the FUNC portion **MUST** be set to zero, and the Argument Length (AL) **MUST** be zero.

Certain SRv6 Endpoint Behaviors (e.g., End.DT2M) support arguments. As specified in Section 3.2.1 of [RFC9252], the SRv6 SID Structure Sub-Sub-TLV **MUST** be included when signaling an SRv6 SID corresponding to an SRv6 Endpoint Behavior that supports argument. This ensures that the receiving router can perform consistency verification of the argument and correctly encode the ARG value within the SRv6 SID.

In certain use cases, the SRv6 SID can be signaled as a complete structure, with the LOC:FUNC:ARG components fully encoded within the SID. However, there are scenarios where the SRv6 SID, consisting only of the LOC:FUNC portion, is signaled in one advertisement, while the ARG value is either signaled through a separate advertisement or learned via an alternative mechanism. It is the responsibility of the SRv6 source node to append the ARG component to the LOC:FUNC portion, thereby constructing the complete SRv6 SID (LOC:FUNC:ARG). This fully formed SID can then be utilized in the data plane, either as the IPv6 destination address of a packet or as a segment within the Segment Routing Header (SRH) [RFC8754], as required.

Since arguments may be optional, the SRv6 endpoint node that owns the SID **MUST** advertise the SRv6 SID Structure Sub-Sub-TLV along with the LOC:FUNC portion of the SRv6 SID to indicate whether arguments are supported for that specific SID. A zero AL value indicates that the node does not accept an argument for the given SRv6 SID. Conversely, a non-zero AL value specifies the size of the supported argument, along with the Locator Block Length (LBL), Locator Node Length (LNL), and Function Length (FL) parameters, which define the offset from which the node expects the ARG to be encoded. All bits beyond LBL + LNL + FL + AL **MUST** be set to zero.

The advertisement of the ARG value may be performed either by the node that owns the SRv6 SID and is advertising the LOC:FUNC portion of that SID or by another node/mechanism. The advertisement of the ARG value **MUST** specify the size of the argument, its value, and the associated SRv6 Endpoint Behavior of the SID. Additionally, the specification of the association of the ARG advertisement with the corresponding SID(s) for which the argument applies is **REQUIRED**.

3. End.DT2M Signaling for EVPN ESI Filtering

As specified in [RFC9252], the LOC:FUNC portion of the SRv6 SID with End.DT2M behavior is signaled via the Inclusive Multicast Ethernet Tag route, while the Ethernet Segment Identifier (ESI) Filtering ARG (denoted as Arg.FE2 in [RFC8986]) is signaled via the Ethernet A-D (Auto-Discovery) per ES route. The following subsections provide a more detailed specification of the signaling and processing mechanisms compared to [RFC9252].

ESI Filtering is a split-horizon mechanism used for multihoming [RFC7432] or Ethernet-Tree (E-Tree) procedures [RFC8317]. ESI Filtering is not applicable in scenarios where:

- No E-Tree leaf Broadcast, Unknown Unicast, or Multicast (BUM) traffic exists,
- No multihoming is present,
- No split-horizon mechanism is required, or
- The "Local Bias" method (as specified in [RFC8365]) is employed.

In this document, "ESI Filtering" is used as a general reference to the procedure performed by the disposition Provider Edge (PE) router to prevent forwarding of BUM traffic to local Ethernet Segments or local leaf attachment circuits, based on the presence of the ESI Filtering ARG.

The signaling and processing descriptions outlined in the following sections also apply to End.DT2M behavior flavors designed for SRv6 SID list compression [RFC9800]. In deployments where a mix of compressed and uncompressed SIDs is present, the behaviors advertised in the Ethernet A-D per ES routes and Inclusive Multicast Ethernet Tag routes **MAY** consist of a combination of compressed and uncompressed End.DT2M behavior flavors. The procedures in this document remain valid for such deployments provided that the AL consistency checks between EVPN Route Type 1 and EVPN Route Type 3, as described in the following subsections, are satisfied.

3.1. Advertisement of Ethernet A-D per ES Route

Ethernet A-D per ES routes, as defined in [RFC7432], are utilized to enable split-horizon filtering and fast convergence in multihoming scenarios. Additionally, Ethernet A-D per ES routes facilitate egress filtering of BUM traffic originating from a leaf, as specified in [RFC8317].

When ESI Filtering is not in use, no ESI Filtering ARG is required to be conveyed. However, for backward compatibility and consistency with [RFC9252], the advertisement of this route **SHOULD** include the BGP Prefix-SID attribute with an SRv6 L2 Service TLV carrying an SRv6 Service SID set to ::0 in the SRv6 SID Information Sub-TLV, with the SRv6 Endpoint Behavior set to End.DT2M. Since the End.DT2M behavior supports the use of an ARG, an SRv6 SID Structure Sub-Sub-TLV **MUST** be included. As no ARG value is required to be signaled in this case, the AL **MUST** be set to 0.

The following is an example representation of the BGP Prefix-SID attribute encoding in this case:

```
BGP Prefix-SID attribute:
  SRv6 L2 Service TLV:
    SRv6 SID Information Sub-TLV:
      SID: ::
      Behavior: End.DT2M
    SRv6 SID Structure Sub-Sub-TLV:
      LBL: 32, LNL: 16, FL: 16, AL: 0, TPOS-L: 0, TPOS-O: 0
```

Figure 1: EVPN Route Type 1 Without ARG for ESI Filtering

When ESI Filtering is in use, the advertisement of this route **MUST** include the BGP Prefix-SID attribute with an SRv6 L2 Service TLV carrying the SRv6 Service SID that contains the ESI Filtering ARG value within the SRv6 SID Information Sub-TLV (when not using the Transposition Scheme), with the SRv6 Endpoint Behavior set to End.DT2M. Since the End.DT2M behavior supports the use of an ARG, an SRv6 SID Structure Sub-Sub-TLV **MUST** be included. Additionally, as a non-zero ARG value is being signaled, the AL **MUST** be set to the size of the ARG, and the size **SHOULD** be a multiple of 8 to ensure consistency across implementations for ease of operations. The SRv6 SID Structure Sub-Sub-TLV **MUST** set the LBL, LNL, and FL fields with values that indicate the offset at which the ARG value is encoded within the 128-bit SRv6 SID.

The following is an example representation of the BGP Prefix-SID attribute encoding in this scenario for a 16-bit argument value of 'aaaa':

```

BGP Prefix-SID attribute:
  SRv6 L2 Service TLV:
    SRv6 SID Information Sub-TLV:
      SID: ::aaaa:0:0:0
      Behavior: End.DT2M
    SRv6 SID Structure Sub-Sub-TLV:
      LBL: 32, LNL: 16, FL: 16, AL: 16, TPOS-L: 0, TPOS-O: 0

```

Figure 2: EVPN Route Type 1 with ARG for ESI Filtering

In the examples above, it would have been possible to set the LBL, LNL, and FL values to 0 and to encode the SRv6 SID as either ::0 or aaaa::. However, such an encoding would not be backward compatible with [RFC9252], as further detailed in [Section 4](#).

Therefore, it is **REQUIRED** that the LBL, LNL, and FL values be set in accordance with the SID structure for End.DT2M SRv6 Service SIDs, ensuring compliance with [RFC9252].

3.2. Advertisement of Inclusive Multicast Ethernet Tag Route

The Inclusive Multicast Ethernet Tag route, as defined in [RFC7432], is used to advertise multicast traffic reachability information via Multiprotocol BGP (MP-BGP) to all other PE routers within a given EVPN instance. When utilizing SRv6 transport, the advertisement of this route **MUST** include the BGP Prefix-SID attribute with an SRv6 L2 Service TLV to indicate the use of SRv6.

Regardless of whether ESI Filtering is in use, the SRv6 Service SID **MUST** include only the LOC:FUNC portion within the SRv6 SID Information Sub-TLV (when not utilizing the Transposition Scheme), with the SRv6 Endpoint Behavior set to End.DT2M. Since the End.DT2M behavior supports the use of an ARG, an SRv6 SID Structure Sub-Sub-TLV **MUST** be included. The LBL, LNL, and FL fields **MUST** be set to indicate the structure of the SRv6 Service SID being advertised.

When ESI Filtering is not in use, no ARG is expected to be received by the router along with the advertised SRv6 Service SID. Therefore, the AL **MUST** be set to 0.

The following is an example representation of the BGP Prefix-SID attribute encoding in this case:

```

BGP Prefix-SID attribute:
  SRv6 L2 Service TLV:
    SRv6 SID Information Sub-TLV:
      SID: 2001:db8:1:fbid1::
      Behavior: End.DT2M
    SRv6 SID Structure Sub-Sub-TLV:
      LBL: 32, LNL: 16, FL: 16, AL: 0, TPOS-L: 0, TPOS-O: 0

```

Figure 3: EVPN Route Type 3 Without ESI Filtering

When ESI Filtering is in use, the router expects to receive traffic in the data path to the SRv6 Service SID that it has signaled along with the ARG portion embedded in it. Consequently, the AL **MUST** be set to the size of the ARG supported by the advertising router for the specific SRv6 Service SID. The AL value is unique per End.DT2M behavior signaled by the egress PE. Therefore, the egress PE **MUST** use the same AL for all local Ethernet Segments with attachment circuits within the same broadcast domain.

The following is an example representation of the BGP Prefix-SID attribute encoding for this scenario with a 16-bit argument:

```
BGP Prefix-SID attribute:
  SRv6 L2 Service TLV:
    SRv6 SID Information Sub-TLV:
      SID: 2001:db8:1:fbd1::
      Behavior: End.DT2M
    SRv6 SID Structure Sub-Sub-TLV:
      LBL: 32, LNL: 16, FL: 16, AL: 16, TPOS-L: 0, TPOS-O: 0
```

Figure 4: EVPN Route Type 3 with ESI Filtering

When ESI Filtering is in use, the advertising router **MUST** ensure that the AL signaled in the EVPN Route Type 3 is equal to the AL signaled in the corresponding EVPN Route Type 1.

3.3. Processing at Ingress PE

An ingress PE receives the LOC:FUNC portion of the SRv6 Service SID to be used for BUM traffic through EVPN Route Type 3 advertisements.

When ESI Filtering is not in use, the SRv6 Service SID to be used consists solely of the LOC:FUNC portion received via EVPN Route Type 3.

When ESI Filtering is in use, the ESI Filtering ARG of the SRv6 Service SID is signaled through the Ethernet A-D per ES route. The ARG, in combination with the LOC:FUNC portion received via EVPN Route Type 3, forms the SRv6 Service SID to be used.

Since the LOC:FUNC and ARG portions of the SRv6 Service SID are signaled via different route advertisements, there may be cases where the ingress PE receives inconsistent AL values from the two route types. If the ingress PE expects ESI Filtering to be in use (i.e., when forwarding BUM traffic to other PEs attached to a shared Ethernet Segment) but does not receive a usable ARG value during processing, it **SHOULD** log a message to facilitate troubleshooting.

The ingress PE router **MUST** follow the processing steps outlined below when handling SRv6 Service SID advertisements:

1. If AL=0 is signaled via EVPN Route Type 3, then the egress PE either does not support ESI Filtering or does not require an ESI Filtering ARG for the specific SID. In this case, the SRv6 Service SID is formed using only the LOC:FUNC portion, and all bits after LBL + LNL + FL **MUST** be set to zero for encoding on the data path. Additionally, the router **MUST** ignore the SID value and its SID structure advertised in the corresponding EVPN Route Type 1.
2. If a non-zero AL is signaled via EVPN Route Type 3, then the matching EVPN Route Type 1 for the Ethernet Segment is located and the presence of an SRv6 SID advertisement with the End.DT2M behavior is verified.
 - a. If the presence of such a SRv6 SID is not verified, or if the AL is zero in the EVPN Route Type 1, then no usable ARG value is available. The SRv6 Service SID **MUST** be formed as described in (1) above.
 - b. If the AL values in EVPN Route Type 1 and EVPN Route Type 3 are both non-zero but not equal, then no usable ARG value is available. This inconsistency in signaling from the egress PE indicates a configuration error. To prevent potential looping, BUM traffic **MUST NOT** be forwarded for such routes from the specific Ethernet Segment. Implementations **SHOULD** log an error message for troubleshooting this condition.
 - c. If the AL values in EVPN Route Type 1 and EVPN Route Type 3 are both non-zero and equal, then the ARG value from EVPN Route Type 1 is considered valid. This ARG value **MUST** be encoded within the SRv6 SID (LOC:FUNC) at the ARG offset as specified in the SID structure (i.e., LBL + LNL + FL) in EVPN Route Type 3. All bits beyond LBL + LNL + FL + AL **MUST** be set to zero.

Using the procedures above with the examples in Figures 1 and 3, the SRv6 Service SID encoding for the data plane without an ESI Filtering ARG is as follows:

```
EVPN Route Type 3:  
SID: 2001:db8:1:fbd1::  
Structure: LBL: 32, LNL: 16, FL: 16, AL: 0  
  
SRv6 Service SID Encoded for Datapath: 2001:db8:1:fbd1::
```

Figure 5: SRv6 Service SID Encoding for Data Plane Without ARG

Using the procedures above with the examples in Figures 2 and 4, the SRv6 Service SID encoding for the data plane along with an ESI Filtering ARG is as follows:


```
EVPN Route Type 1:
  SID: ::aaaa:0:0:0
  Structure: LBL: 32, LNL: 16, FL: 16, AL: 16

EVPN Route Type 3:
  SID: 2001:db8:1:fb1::
  Structure: LBL: 32, LNL: 16, FL: 16, AL: 16

SRv6 Service SID Encoded for Datapath: 2001:db8:1:fb1:aaaa::
```

Figure 6: SRv6 Service SID Encoding for Data Plane with ARG

[Figure 7](#) provides another example that illustrates the signaling and processing of multiple bridge domains in a deployment design.

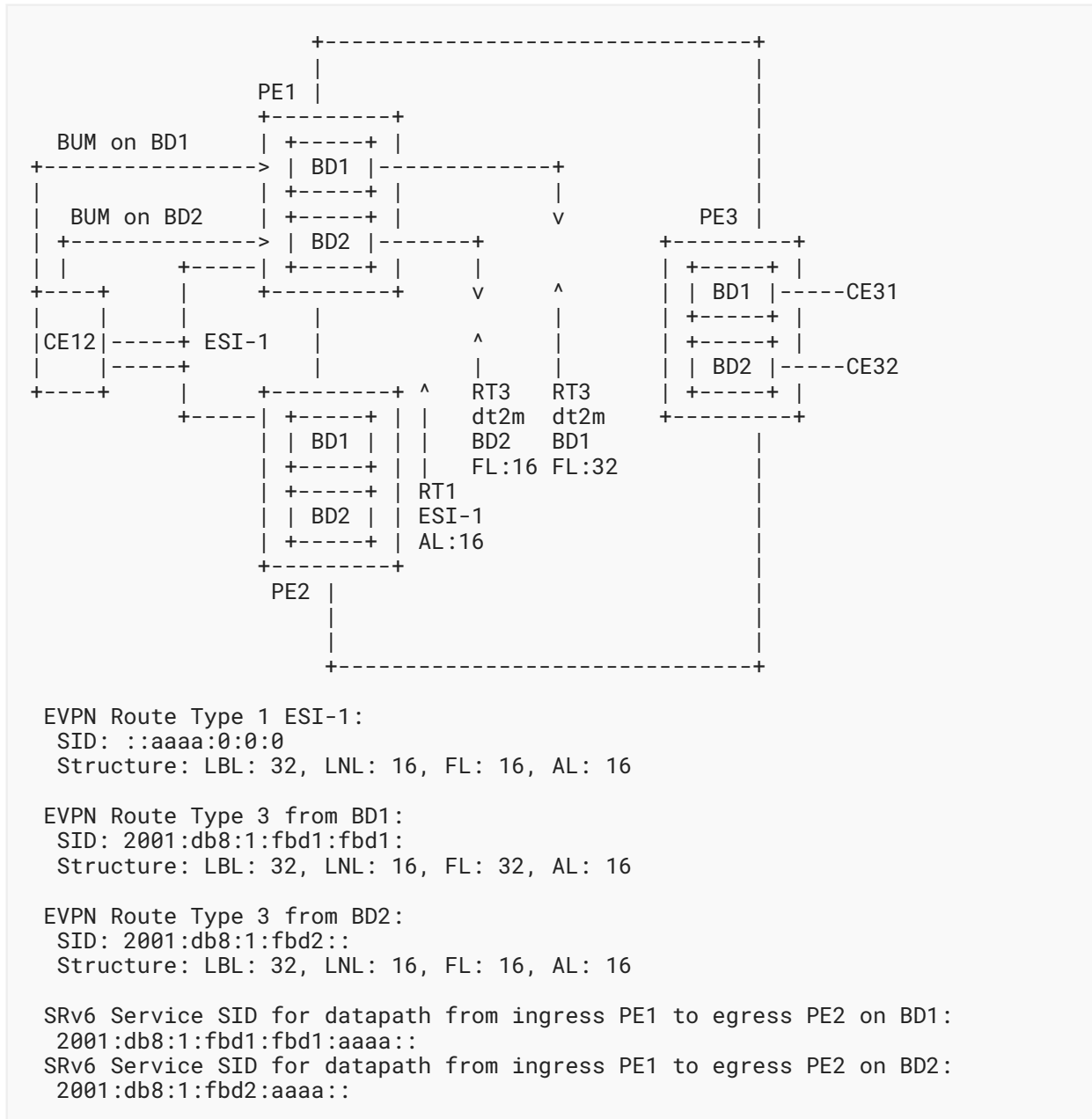


Figure 7: Example with Multiple Bridge Domains

4. Backward Compatibility

Existing implementations that rely on the bitwise logical-OR operation, as specified in [Section 6.3](#) of [\[RFC9252\]](#), function correctly only when the SID structures of the two EVPN route types are identical.

Backward compatibility with implementations performing the bitwise logical-OR operation is maintained when EVPN Route Type 3 and its corresponding EVPN Route Type 1 advertise SIDs with the same SID structure, as outlined in Sections 3.1 and 3.2.

However, when the SID structures of the two route types are not identical, the bitwise logical-OR operation specified in [RFC9252] cannot be applied. Instead, the alternative method specified in Section 3.3 **MUST** be used to correctly derive the SRv6 Service SID in such cases.

5. IANA Considerations

This document has no IANA actions.

6. Security Considerations

This document provides a more detailed specification related to the signaling and processing of SRv6 SID advertisements for SRv6 Endpoint Behaviors with arguments. As such, it does not introduce any new security considerations over and above those already covered by [RFC9252].

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Authors' Addresses

Ketan Talaulikar

Cisco Systems

India

Email: ketant.ietf@gmail.com

Kamran Raza

Cisco Systems

Canada

Email: skraza@cisco.com

Jorge Rabadan

Nokia

United States of America

Email: jorge.rabadan@nokia.com

Wen Lin

Juniper Networks

United States of America

Email: wwlin@juniper.net