

Workgroup: SPRING Working Group
Internet-Draft:
draft-salih-spring-srv6-inter-domain-sids-03
Published: 23 June 2023
Intended Status: Standards Track
Expires: 25 December 2023
Authors: K. Salih S. Hegde
 Juniper Networks Juniper Networks
 M. Rajesh R. Bonica
 Juniper Networks Juniper Networks
 H. wang Shaofu. Peng
 Huawei Technologies ZTE Corporation

SRv6 inter-domain mapping SIDs

Abstract

This document describes three new SRv6 end-point behaviors, called END.REPLACE, END.REPLACEB6 and END.DB6. These behaviors are used in distributed inter-domain solutions and are normally executed on border routers. They also can be used to provide multiple intent-based paths across these domains.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at <https://datatracker.ietf.org/drafts/current/>.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on 25 December 2023.

Copyright Notice

Copyright (c) 2023 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with

respect to this document. Code Components extracted from this document must include Revised BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Revised BSD License.

Table of Contents

- [1. Overview](#)
- [2. Requirements Language](#)
- [3. Usecases](#)
 - [3.1. usecase 1](#)
 - [3.2. usecase 2](#)
- [4. SRv6 SID Behaviors](#)
 - [4.1. END.REPLACE](#)
 - [4.2. END.REPLACEB6](#)
 - [4.3. END.DB6](#)
- [5. Interworking Procedures](#)
 - [5.1. Option C Transport Interworking](#)
 - [5.2. Option B service interworking](#)
- [6. IANA Considerations](#)
- [7. Security Considerations](#)
- [8. Contributors](#)
- [9. Acknowledgements](#)
- [10. References](#)
 - [10.1. Normative References](#)
 - [10.2. Informative References](#)
- [Authors' Addresses](#)

1. Overview

[Segment Routing \(SR\)](#) [[RFC8402](#)] allows source nodes to steer packets through SR paths. It can be implemented over [IPv6](#) [[RFC8200](#)] or [MPLS](#) [[RFC3031](#)]. When SR is implemented over IPv6, it is called [SRv6](#) [[RFC8986](#)].

This document describes three new SRv6 end-point behaviors, called END.REPLACE, END.REPLACEB6 and END.DB6. These behaviors are used to build paths across SRv6 domains. They also facilitate end-to-end SRv6 intent-based path stitching.

2. 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.

3. Usecases

3.1. usecase 1

This use-case is mentioned in Section 4.1.1 of [\[I-D.hegde-spring-mpls-seamless-sr\]](#).

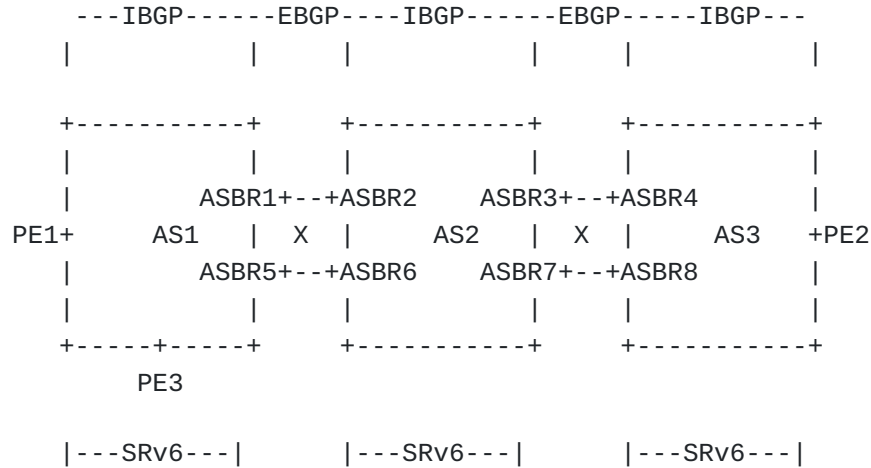


Figure 1: Multiple ASes connected with E-BGP

[Figure 1](#) depicts three ASes (AS1, AS2 and AS3). All the three domains deploy SRv6. Inter-provider Option C[[RFC4364](#)] connectivity is maintained from PE1 to PE2.

3.2. usecase 2

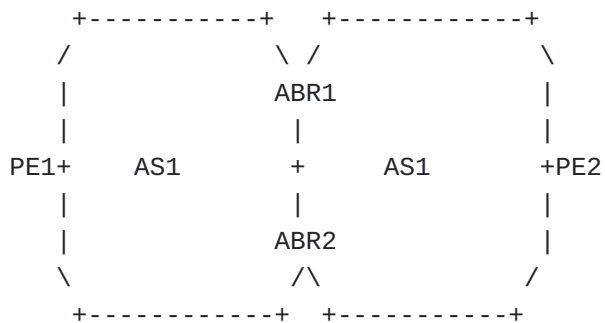


Figure 2: Single AS with different IGP domains

The above diagram [Figure 2](#) shows two different SRv6 IGP domains. Services are running between PE1 and PE2 in option B [[RFC4364](#)] style. The requirement here is to avoid service route lookup on ABR1 and ABR2 to provide option B style end to end connectivity

4. SRv6 SID Behaviors

4.1. END.REPLACE

The END.REPLACE behavior is applicable in the [Multiple ASes Connected With E-BGP](#) ([Section 3.1](#)) use-case.

The End.REPLACE SID cannot be the last segment in SRH or SR Policy.

Any SID instance of this behavior is associated with a set, J, of one or more L3 adjacencies of immediate BGP neighbors

When Node N receives a packet destined to S and S is a locally instantiated End.REPLACE SID, Node N executes the following procedure:

```
S01. When an SRH is processed {
S02.   If (Segments Left == 0) {
S03.     Stop processing the SRH, and proceed to process the next
         header in the packet, whose type is identified by
         the Next Header field in the routing header. Procedure is as
         per Section 4.1.1 of [RFC8986].
S04.   }
S05.   If (IPv6 Hop Limit <= 1) {
S06.     Send an ICMP Time Exceeded message to the Source Address wi
         (Hop limit exceeded in transit), interrupt packet processin
S07.   }
S08.   Decrement IPv6 Hop Limit by 1
S09.   Update IPv6 DA with new destination address(SID) mapped with E
S10.   Submit the packet to the IPv6 module for transmission
         to the new destination via a member of J.
S11. }
```

4.2. END.REPLACEB6

The END.REPLACEB6 behavior is applicable in the [Multiple ASes Connected With E-BGP](#) ([Section 3.1](#)) use-case.

The End.REPLACEB6 SID cannot be the last segment in a SRH or SR Policy.

Node N is configured with an IPv6 address T (e.g., assigned to its loopback).

When Node N receives a packet destined to S and S is a locally instantiated End.REPLACEB6 SID, Node N executes the following procedure:

```
S01. When an SRH is processed {
S02.   If (Segments Left == 0) {
S03.     Stop processing the SRH, and proceed to process the next
         header in the packet, whose type is identified by
         the Next Header field in the routing header. Procedure is as
         per Section 4.1.1 of [RFC8986].
S04.   }
S05.   If (IPv6 Hop Limit <= 1) {
S06.     Send an ICMP Time Exceeded message to the Source Address wi
         (Hop limit exceeded in transit), interrupt packet processin
S07.   }
S08.   Decrement IPv6 Hop Limit by 1
S09.   Update IPv6 DA with new destination address(SID) mapped with E
S10.   Push an IPv6 header with an SRH.
S11.   Set outer IPv6 SA = T and outer IPv6 DA to the first SID in th
S12.   Set outer Payload Length, Traffic Class, Hop Limit, and Flow L
S13.   Set the outer Next Header value
S14.   Submit the packet to the IPv6 module for transmission to the F
S15. }
```

Note :

S10 - S13. Implementation may choose to avoid outer encapsulation
S12. The Payload Length, Traffic Class, Hop Limit, and Next Heade
computed as per [RFC6437].

4.3. END.DB6

For the use-case mentioned under [Section 3.2](#) END.DB6 SID is applicable.

The End.DB6 SID MUST be the last segment in SRH or SR Policy.

Node N is configured with an IPv6 address T (e.g., assigned to its loopback).

When Node N receives a packet destined to S and S is a locally instantiated End.DB6 SID, Node N executes the following procedure:

```

S01. When an SRH is processed {
S02.   If (Segments Left != 0) {
S03.     Send an ICMP Parameter Problem to the Source Address,
        Code 0 (Erroneous header field encountered),
        Pointer set to the Segments Left field,
        interrupt packet processing and discard the packet.
S04.   }
S05.   If (Upper-Layer header type == 4(IPv4) OR Upper-Layer header
        Upper-Layer header type == 143(Ethernet)) {
S06.     Remove the outer IPv6 header with all its extension headers.
S07.     Push the new IPv6 header with the SRv6 SIDs associated with
S08.     Set outer IPv6 SA = T and outer IPv6 DA to the first SID in
S09.     Set outer Payload Length, Traffic Class, Hop Limit, and Flow
S10.     Set the outer Next Header value
S11.     Submit the packet to the IPv6 module for transmission to Fir
S12.   } else {
S13.     Process as per Section 4.1.1 of [RFC8986].
S14.   }
S15. }

```

Note :

S09. The Payload Length, Traffic Class, Hop Limit, and Next Header computed as per [RFC6437].

5. Interworking Procedures

Here we will describe the control plane and data plane procedures by taking examples.

Node n has a classic IPv6 loopback address $A_n::1/128$. One of the SIDs at node n with locator block B and function F is represented by $B:n:F::sid_num$.

A SID list is represented as

<S1, S2, S3>

where S1 is the first SID to visit, S2 is the second SID to visit and S3 is the last SID to visit along the SR path.

5.1. Option C Transport Interworking

Here we will discuss the use-case mentioned under [Section 3.1](#)

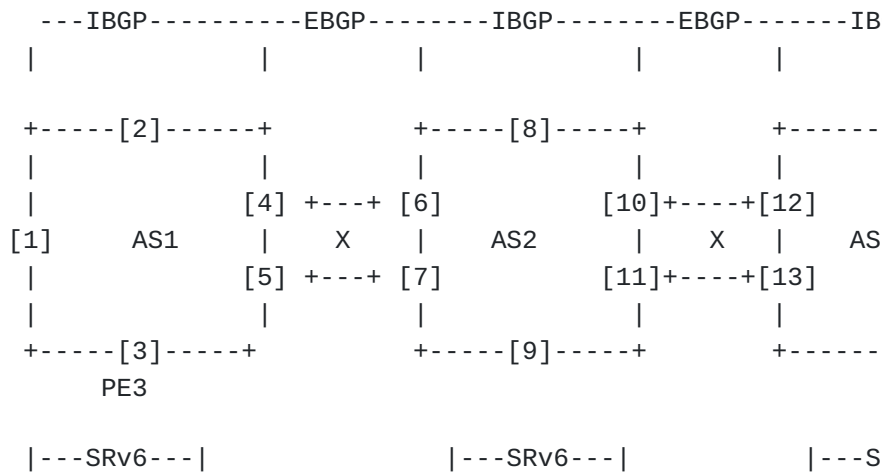


Figure 3: Option C Style Interworking

Node [1] acts as ingress PE and Node [16] acts as egress PE.

Nodes [2], [3], [8], [9], [14] and [15] are P routers.

Nodes [4], [5], [6], [7], [10], [11], [12] and [13] are ASBR routers.

A VPN route is advertised via service RRs between an egress PE (node 16) and an ingress PE (node 1). The example below shows IBGP-CT connection between border routers in each domain and single hop EBGP-CT for inter-domain connections. However the forwarding procedure for the sids remains the same irrespective of the various inter-domain protocol extensions used to advertise the sids. AS1, AS2 and AS3 has SRTE policy for the required intent paths.

Control plane example:

For simplicity only one path is tracked.

For a route if the next hop is one hop away then while advertising u
next hop is multi hop away then while advertising use END.REPLACEB6
required as it is just replace and forward on specific link while in

Routing Protocol(RP) @16:

- * In ISIS advertise locator B:16::/48 and an END SID B:16::END
- * BGP AFI=1,SAFI=128 originates a VPN route RD:V/v via A:16::1
This route is advertised to service RR with color extended c
- * BGP originates prefix A:16::1 with color red to ASBR [12] wi

RP @12:

- * BGP receives the route A:16::1 over the ibgp session and rea
it advertises the SRV6 SID B:12:End.B6.Encaps::1 in the prot
was received with End SID, this node allocates a End.B6.Enca

RP @10:

- * BGP receives the route A:16::1 over the ebgp session and rea
it advertises the SRV6 SID B:10:REPLACE::1 in the protocol e
single hop e-bgp session this node allocates a REPLACE sid.

RP @6:

- * BGP receives the route A:16::1 over the ibgp session and rea
it advertises the SRV6 SID B:6:REPLACEB6::1 in the protocol
multihop i-bgp session this node allocates a REPLACEB6 sid.

RP @4:

- * BGP receives the route A:16::1 over the ebgp session and rea
it advertises the SRV6 SID B:4:REPLACE::1 in the protocol ex
single hop e-bgp session this node allocates a REPLACE sid.

RP @1:

- * BGP receives the route A:16::1 with color red over the ibgp
- * BGP AFI=1, SAFI=128 learn service prefix RD:V/v, next hop A:
with SRV6 SID B:16:DT4

FIB State:

```
@1: IPv4 VRF V/v => H.Encaps.red <B:2:END::1, B:4:REPLACE::1, B:
    sid B:2:END::1 belongs to the SR-policy in AS1.
@2: IPv6 Table: B:2:END::1 => Update DA with B:4:REPLACE::1, dec
@4: IPv6 Table: B:4:REPLACE::1 => Update DA with B:6:REPLACEB6::
    ebgp neighbor; the SL remains at 1.
@6: IPv6 Table: B:6:REPLACEB6::1 => Update DA with B:10:REPLACE:
    with SRH where the new SRH SIDs belong to SR policy in AS2.
@8: IPv6 Table: B:8:END::1 => Update outer IPv6 packet DA with B
@10: IPv6 table: B:10:END::1 => Decap Outer IPv6 header and look
    and forward on the interface/interfaces identified by the e
@12: IPv6 Table B:12:End.B6.Encaps::1 => Update DA with Next Seg
    and do a fresh H.Encaps.red <B:15:END::1, B:16:END::1> with
@15: IPv6 Table B:15:END::1 => Update outer IPv6 packet DA with
@16: IPv6 Table B:16:END::1 => Decap the outer header and lookup
    results in Decap and inner IPv4 packet DA lookup in the cor
```

Note: At [1] we have optimized the solution by single Encapsulat with a SRH header.This can be supported by Most of the ASI Here we can even use two encapsulation, this mechanism will also work.

5.2. Option B service interworking

Here we will discuss the use-case mentioned under [Section 3.2](#)

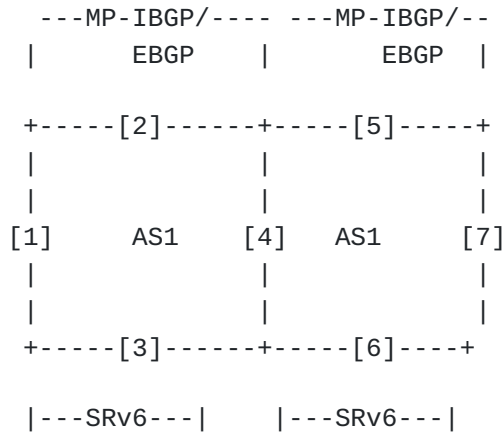


Figure 4: Option B style Service Interworking

Nodes [1] and [7] are PE routers. Node [4] is an option B style configured ABR/RR.

Control Plane example:

Routing Protocol(RP) @7:

- * BGP AFI=1,SAFI=128 originates a VPN route RD:V/v via A:7::1 and attribute B:7:DT4::1. This route is advertised to service RR [4

RP @4:

- * BGP receives the route over MP-IBGP/MP-EBGP session and readvert it advertises the SRv6 SID B:4:DB6::1 in the Prefix-SID attribute having SRv6 service SID B:7:DT4::1; the same DB6 SID B:4:DB6::1 B:7:DT4::2 comes then a different DB6 SID B:4:DB6::2 will be applied per CE sid; the translation at border also ensure per CE sid.

RP @1:

- * BGP AFI=1, SAFI=128 learn service prefix RD:V/v, next hop A:4:: with SRv6 SID B:4:DB6::1

FIB State:

@1: IPv4 VRF V/v => H.Encaps.red <B:4:DB6::1> with SRH, SRH NextHead

@4: IPv6 Table: B:4:DB6::1 => Decapsulate the incoming IPv6 header a

@7: IPv6 Table: B:7:DT4::1 => Decapsulate the header and lookup th

6. IANA Considerations

This document requires no IANA action.

The authors will request an early allocation from the "SRv6 Endpoint Behaviors" sub-registry of the "Segment Routing Parameters" registry.

7. Security Considerations

Because SR inter-working requires co-operation between inter-working domains, this document introduces no security consideration beyond those addressed in [[RFC8402](#)], [[RFC8754](#)] and [[RFC8986](#)].

8. Contributors

Jie Dong
Huawei Technologies
Email: jie.dong@huawei.com

Swamy SRK
Juniper Networks
Email: swamys@juniper.net

G. Sri Karthik Goud
Juniper Networks
Email: gkarthik@juniper.net

9. Acknowledgements

Thanks to Ram Santhanakrishnan, Srihari Sangli, Rajendra Prasad Bollam and Kiran Kushalad for their valuable comments.

10. References

10.1. Normative References

- [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>>.
- [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>>.
- [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>>.
- [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>>.
- [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>>.
- [RFC8986] Filsfils, C., Ed., Camarillo, P., Ed., Leddy, J., Voyer, D., Matsushima, S., and Z. Li, "Segment Routing over IPv6 (SRv6) Network Programming", RFC 8986, DOI 10.17487/RFC8986, February 2021, <<https://www.rfc-editor.org/info/rfc8986>>.

10.2. Informative References

- [I-D.hegde-spring-mpls-seamless-sr] Hegde, S., Bowers, C., Xu, X., Gulko, A., Bogdanov, A., Uttaro, J., Jalil, L., Khaddam, M., Alston, A., and L. M. Contreras, "Seamless SR Problem Statement", Work in Progress, Internet-Draft, draft-hegde-spring-mpls-

seamless-sr-07, 8 July 2022, <<https://datatracker.ietf.org/doc/html/draft-hegde-spring-mpls-seamless-sr-07>>.

[RFC3031] Rosen, E., Viswanathan, A., and R. Callon, "Multiprotocol Label Switching Architecture", RFC 3031, DOI 10.17487/RFC3031, January 2001, <<https://www.rfc-editor.org/info/rfc3031>>.

Authors' Addresses

Salih K A
Juniper Networks
Embassy Business Park
Bangalore 560093
KA
India

Email: salih@juniper.net

Shraddha Hegde
Juniper Networks
Embassy Business Park
Bangalore 560093
KA
India

Email: shraddha@juniper.net

Rajesh
Juniper Networks
Embassy Business Park
Bangalore 560093
KA
India

Email: mrajesh@juniper.net

Ron Bonica
Juniper Networks
Herndon, Virginia 20171
United States of America

Email: rbonica@juniper.net

Haibo Wang
Huawei Technologies
Huawei Campus, No. 156 Beiqing Road
Beijing
100095

China

Email: rainsword.wang@huawei.com

Peng Shaofu
ZTE Corporation
China

Email: peng.shaofu@zte.com.cn