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Segment Routing Prefix SID extensions for BGP
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Abstract

The Segment Routing (SR) architecture allows a node to steer a packet flow through any topological path and service chain by leveraging source routing. The ingress node prepends an SR header to a packet containing a set of segment identifiers (SID). Each SID represents a topological or a service-based instruction. Per-flow state is maintained only on the ingress node of the SR domain. An SR domain is defined as a single administrative domain for global SID assignment.

This document defines an optional, transitive BGP attribute for announcing BGP Prefix Segment Identifiers (BGP Prefix-SID) information.

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.

Status of This Memo

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

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1. Introduction

The Segment Routing (SR) architecture leverages the source routing paradigm. A group of inter-connected nodes that use SR forms an SR domain. A segment represents either a topological instruction such as "go to prefix P following shortest path" or a service instruction. Other types of segments may be defined in the future.

A segment is identified through a Segment Identifier (SID). An SR domain is defined as a single administrative domain for global SID assignment. It may be comprised of a single AS or multiple ASes under consolidated global SID administration. Typically, the ingress node of the SR domain prepends an SR header containing segments identifiers (SIDs) to an incoming packet.

As described in [I-D.ietf-spring-segment-routing], when SR is applied to the MPLS dataplane ([I-D.ietf-spring-segment-routing-mpls]), the SID consists of a label.

[I-D.ietf-spring-segment-routing] also describes how segment routing can be applied to an IPv6 dataplane (SRv6) using an IPv6 routing header containing a stack of SR SIDs encoded as IPv6 addresses [I-D.ietf-6man-segment-routing-header]. The applicability and support for Segment Routing over IPv6 is beyond the scope of this document.

A BGP-Prefix Segment (and its BGP Prefix-SID) is a BGP segment attached to a BGP prefix. A BGP Prefix-SID is always a global SID ([I-D.ietf-spring-segment-routing]) within the SR/BGP domain (i.e., the set of Autonomous Systems under a common administration and control and where SR is used) and identifies an instruction to forward the packet over the ECMP-aware best-path computed by BGP to the related prefix. The BGP Prefix-SID is the identifier of the BGP prefix segment. In this document, we always refer to the BGP segment by the BGP Prefix-SID.

This document describes the BGP extension to signal the BGP Prefix-SID. Specifically, this document defines a BGP attribute known as the BGP Prefix-SID attribute and specifies the rules to originate, receive, and handle error conditions for the attribute.

The BGP Prefix-SID attribute defined in this document can be attached to prefixes from Multiprotocol BGP labeled IPv4/IPv6 Unicast ([RFC4760], [RFC8277]). Address Family Identifier (AFI)/ Subsequent Address Family Identifier (SAFI) combinations.

Usage of the BGP Prefix-SID attribute for other AFI/SAFI combinations is not defined herein but may be specified in future specifications.

[I-D.ietf-spring-segment-routing-msdc] describes example use cases where the BGP Prefix-SID is used for the above AFI/SAFI combinations.

It should be noted that:

- A BGP Prefix-SID MAY be global between domains when the interconnected domains agree on the SID allocation scheme. Alternatively, when interconnecting domains, the ASBRs of each domain will have to handle the advertisement of unique SIDs. The mechanisms for such interconnection are outside the scope of the protocol extensions defined in this document.

- A BGP Prefix-SID MAY be attached to a prefix. In addition, each prefix will likely have a different AS_PATH attribute. This implies that each prefix is advertised individually, reducing the ability to pack BGP advertisements (when sharing common attributes).

2. BGP-Prefix-SID

The BGP Prefix-SID advertised for BGP prefix P indicates that the segment routed path should be used (as described below) if the BGP best path selects the corresponding Network Layer Reachability Information (NLRI).

2.1. MPLS BGP Prefix SID

The BGP Prefix-SID is realized on the MPLS dataplane ([I-D.ietf-spring-segment-routing-mpls]) in the following way:

The operator assigns a globally unique label index, L_I, to a locally sourced prefix of a BGP speaker N which is advertised to all other BGP speakers in the SR domain.

According to [I-D.ietf-spring-segment-routing], each BGP speaker is configured with a label block called the Segment Routing Global Block (SRGB). While [I-D.ietf-spring-segment-routing] recommends using the same SRGB across all the nodes within the SR domain, the SRGB of a node is a local property and could be different on different speakers. The drawbacks of the use case where BGP speakers have different SRGBs are documented in [I-D.ietf-spring-segment-routing] and [I-D.ietf-spring-segment-routing-msdc].

If traffic-engineering within the SR domain is required, each node may also be required to advertise topological information and Peering SIDs for each of its links and peers. This information is required to perform the explicit path computation and to express

an explicit path as a list of SIDs. The advertisement of topological information and peer segments (Peer SIDs) is done through [I-D.ietf-idr-bgpls-segment-routing-epe].

If the BGP speakers are not all configured with the same SRGB, and if traffic-engineering within the SR domain is required, each node may be required to advertise its local SRGB in addition to the topological information.

This document assumes that BGP-LS is the preferred method for collecting both peer segments (Peer SIDs) and SRGB information through [RFC7752], [I-D.ietf-idr-bgpls-segment-routing-epe], and [I-D.ietf-idr-bgp-ls-segment-routing-ext]. However, as an optional alternative for the advertisement of the local SRGB without the topology nor the peer SIDs, hence without applicability for TE, the Originator SRGB TLV of the prefix-SID attribute is specified in Section 3.2 of this document.

As defined in [I-D.ietf-spring-segment-routing], the label index L_I is an offset into the SRGB. Each BGP speaker derives its local MPLS label, L, by adding L_I to the start value of its own SRGB, and programs L in its MPLS dataplane as its incoming/local label for the prefix. It should be noted that while SRGBs and SIDs are advertised using 32-bit values, the derived label is advertised in the 20 right-most bits. See Section 4.1 for more details.

The outgoing label for the prefix is found in the NLRI of the Multiprotocol BGP labeled IPv4/IPv6 Unicast prefix advertisement as defined in [RFC8277]. The label index L_I is only used as a hint to derive the local/incoming label.

Section 3.1 of this document specifies the Label-Index TLV of the BGP Prefix-SID attribute; this TLV can be used to advertise the label index for a given prefix.

In order to advertise the label index of a given prefix P and, optionally, the SRGB, an extension to BGP is needed: the BGP Prefix-SID attribute. This extension is described in subsequent sections.

3. BGP Prefix-SID Attribute

The BGP Prefix-SID attribute is an optional, transitive BGP path attribute. The attribute type code 40 has been assigned by IANA (see Section 7).

The BGP Prefix-SID attribute is defined here to be a set of elements encoded as "Type/Length/Value" tuples (i.e., a set of TLVs). All BGP

Prefix-SID attribute TLVs will start with a 1-octet type and a 2-octet length. The following TLVs are defined in this document:

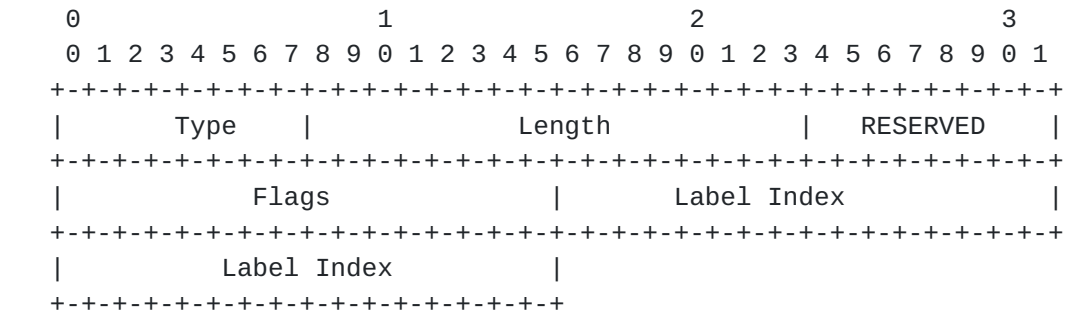
- Label-Index TLV
- Originator SRGB TLV

The Label-Index and Originator SRGB TLVs are used only when SR is applied to the MPLS dataplane.

For future extensibility, unknown TLVs MUST be ignored and propagated unmodified.

3.1. Label-Index TLV

The Label-Index TLV MUST be present in the BGP Prefix-SID attribute attached to Labeled IPv4/IPv6 unicast prefixes ([RFC8277]). It MUST be ignored when received for other BGP AFI/SAFI combinations. The Label-Index TLV has the following format:

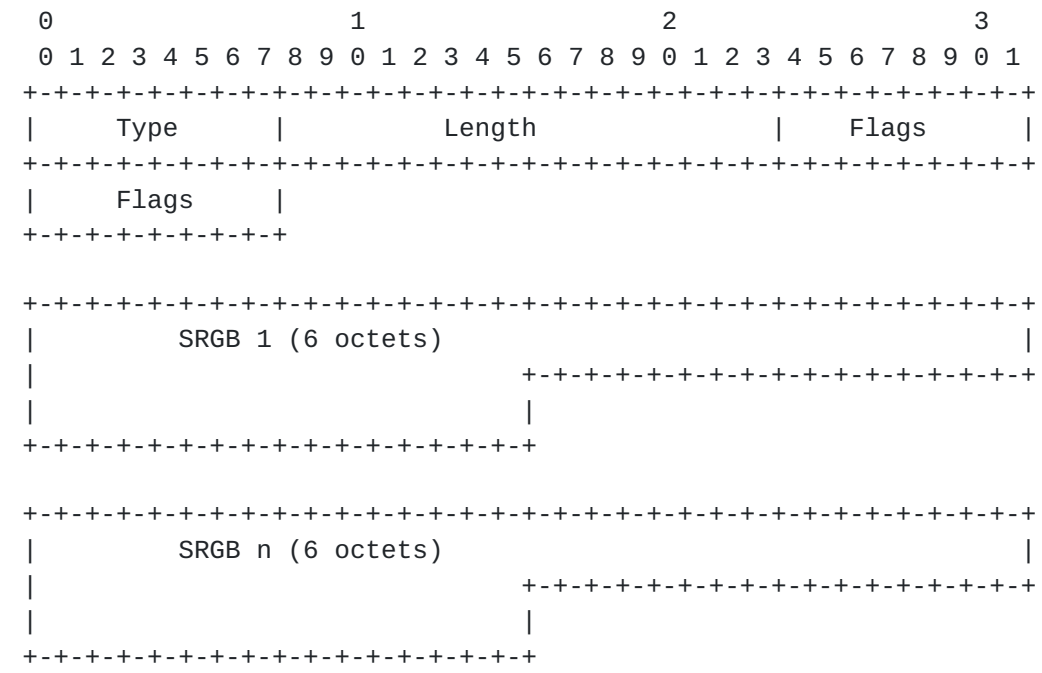


where:

- Type is 1.
- Length: is 7, the total length in octets of the value portion of the TLV.
- RESERVED: 8-bit field. MUST be clear on transmission and MUST be ignored on reception.
- Flags: 16 bits of flags. None are defined by this document. The flag field MUST be clear on transmission and MUST be ignored on reception.
- Label Index: 32-bit value representing the index value in the SRGB space.

3.2. Originator SRGB TLV

The Originator SRGB TLV is an optional TLV and has the following format:



where:

- Type is 3.
- Length is the total length in octets of the value portion of the TLV: 2 + (multiple of 6).
- Flags: 16 bits of flags. None are defined in this document. Flags MUST be clear on transmission and MUST be ignored on reception.
- SRGB: 3 octets of base followed by 3 octets of range. Note that the SRGB field MAY appear multiple times. If the SRGB field appears multiple times, the SRGB consists of multiple ranges that are concatenated.

The Originator SRGB TLV contains the SRGB of the node originating the prefix to which the BGP Prefix-SID is attached. The Originator SRGB TLV MUST NOT be changed during the propagation of the BGP update.

The originator SRGB describes the SRGB of the node where the BGP Prefix SID is attached. It is used to build segment routing policies

when different SRGBs are used in the fabric, for example ([I-D.ietf-spring-segment-routing-msdc]).

The receiving routers concatenate the ranges and build the Segment Routing Global Block (SRGB) as follows:

```
SRGB = [100, 199]
       [1000, 1099]
       [500, 599]
```

The indexes span multiple ranges:

```
index=0 means label 100
...
index 99 means label 199
index 100 means label 1000
index 199 means label 1099
...
index 200 means label 500
...
```

The originator SRGB may only appear in a BGP Prefix-SID attribute attached to Labeled IPv4/IPv6 unicast prefixes ([RFC8277]). It MUST be ignored when received for other BGP AFI/SAFI combinations. Since the Label-Index TLV is required for IPv4/IPv6 prefix applicability, the originator SRGB will be ignored if it is not specified consistent with Section 6.

4. Receiving BGP Prefix-SID Attribute

A BGP speaker receiving a BGP Prefix-SID attribute from an EBGP neighbor residing outside the boundaries of the SR domain MUST discard the attribute unless it is configured to accept the attribute from the EBGP neighbor. A BGP speaker SHOULD log an error for further analysis when discarding an attribute.

4.1. MPLS Dataplane: Labeled Unicast

A BGP session supporting the Multiprotocol BGP labeled IPv4 or IPv6 Unicast ([RFC8277]) AFI/SAFI is required.

The BGP Prefix-SID attribute MUST contain the Label-Index TLV and MAY contain the Originator SRGB TLV. A BGP Prefix-SID attribute received without a Label-Index TLV MUST be considered as "invalid" by the receiving speaker.

The label index provides the receiving BGP speaker with guidance as to the incoming label that SHOULD be assigned by that BGP speaker.

A BGP speaker may be locally configured with an SRGB=[SRGB_Start, SRGB_End]. The preferred method for deriving the SRGB is a matter of local node configuration.

The mechanisms through which a given label index value is assigned to a given prefix are outside the scope of this document.

Given a label index L_I, we refer to (L = L_I + SRGB_Start) as the derived label. A BGP Prefix-SID attribute is designated "conflicting" for a speaker M if the derived label value L lies outside the SRGB configured on M. Otherwise the Label-Index TLV is designated "acceptable" to speaker M.

If multiple different prefixes are received with the same label index, all of the different prefixes MUST have their BGP Prefix-SID attribute considered as "conflicting".

If multiple valid paths for the same prefix are received from multiple BGP speakers or, in the case of [RFC7911], from the same BGP speaker, and the BGP Prefix-SID attributes do not contain the same label index, then the label index from the best path BGP Prefix-SID attribute SHOULD be chosen with a notable exception being when [RFC5004] is being used to dampen route changes.

When a BGP speaker receives a path from a neighbor with an "acceptable" BGP Prefix-SID attribute and that path is selected as the best path, it SHOULD program the derived label as the label for the prefix in its local MPLS dataplane.

When a BGP speaker receives a path from a neighbor with an "invalid" or "conflicting" BGP Prefix-SID attribute or when a BGP speaker receives a path from a neighbor with a BGP Prefix-SID attribute but is unable to process it (e.g., local policy disables the functionality), it MUST ignore the BGP Prefix-SID attribute. For the purposes of label allocation, a BGP speaker MUST assign a local (also called dynamic) label (non-SRGB) for such a prefix as per classic Multiprotocol BGP labeled IPv4/IPv6 Unicast ([RFC8277]) operation.

In the case of an "invalid" BGP Prefix-SID attribute, a BGP speaker MUST follow to the error handling rules specified in Section 6. A BGP speaker SHOULD log an error for further analysis. In the case of a "conflicting" BGP Prefix-SID attribute, a BGP speaker SHOULD NOT treat it as error and SHOULD propagate the attribute unchanged. A BGP Speaker SHOULD log a warning for further analysis, i.e., in the case the conflict is not due to a label index transition.

When a BGP Prefix-SID attribute changes and transitions from "conflicting" to "acceptable", the BGP Prefix-SID attributes for other prefixes may also transition to "acceptable" as well. Implementations SHOULD assure all impacted prefixes revert to using the label indices corresponding to these newly "acceptable" BGP Prefix-SID attributes.

The outgoing label is always programmed as per classic Multiprotocol BGP labeled IPv4/IPv6 Unicast ([RFC8277]) operation. Specifically, a BGP speaker receiving a prefix with a BGP Prefix-SID attribute and a label NLRI field of Implicit NULL [RFC3032] from a neighbor MUST adhere to standard behavior and program its MPLS dataplane to pop the top label when forwarding traffic to the prefix. The label NLRI defines the outbound label that MUST be used by the receiving node.

5. Advertising BGP Prefix-SID Attribute

The BGP Prefix-SID attribute MAY be attached to labeled BGP prefixes (IPv4/IPv6) [RFC8277]. In order to prevent distribution of the BGP Prefix-SID attribute beyond its intended scope of applicability, attribute filtering SHOULD be deployed to remove the BGP Prefix-SID attribute at the administrative boundary of the segment routing domain.

A BGP speaker that advertises a path received from one of its neighbors SHOULD advertise the BGP Prefix-SID received with the path without modification, as long as the BGP Prefix-SID was acceptable. If the path did not come with a BGP Prefix-SID attribute, the speaker MAY attach a BGP Prefix-SID to the path if configured to do so. The content of the TLVs present in the BGP Prefix-SID is determined by the configuration.

5.1. MPLS Dataplane: Labeled Unicast

A BGP speaker that originates a prefix attaches the BGP Prefix-SID attribute when it advertises the prefix to its neighbors via Multiprotocol BGP labeled IPv4/IPv6 Unicast ([RFC8277]). The value of the label index in the Label-Index TLV is determined by configuration.

A BGP speaker that originates a BGP Prefix-SID attribute MAY optionally announce the Originator SRGB TLV along with the mandatory Label-Index TLV. The content of the Originator SRGB TLV is determined by configuration.

Since the label index value must be unique within an SR domain, by default an implementation SHOULD NOT advertise the BGP Prefix-SID

attribute outside an Autonomous System unless it is explicitly configured to do so.

In all cases, the label field of the advertised NLRI ([RFC8277], [RFC4364]) MUST be set to the local/incoming label programmed in the MPLS dataplane for the given advertised prefix. If the prefix is associated with one of the BGP speaker's interfaces, this is the usual MPLS label (such as the Implicit or Explicit NULL label [RFC3032]).

6. Error Handling of BGP Prefix-SID Attribute

When a BGP Speaker receives a BGP Update message containing a malformed or invalid BGP Prefix-SID attribute attached to a Labeled IPv4/IPv6 unicast prefix [RFC8277], it MUST ignore the received BGP Prefix-SID attributes and not advertise it to other BGP peers. In this context, a malformed BGP Prefix-SID attribute is one that cannot be parsed due to not meeting the minimum attribute length requirement, contains a TLV length that doesn't conform to the length constraints for the TLV, or a contains TLV length that would extend beyond the end of the attribute (as defined by the attribute length). This is equivalent to the "Attribute discard" action specified in [RFC7606]. When discarding an attribute, a BGP speaker SHOULD log an error for further analysis.

Consistent with [RFC7606], only the first occurrence of the BGP Prefix-SID attribute will be considered and subsequent occurrences will be discarded. Similarly, only the first occurrence of a BGP Prefix-SID attribute TLV of a given TLV type will be considered unless the specification of that TLV type allows for multiple occurrences.

For future extensibility, unknown TLVs MUST be ignored and propagated unmodified.

7. IANA Considerations

This document defines a BGP path attribute known as the BGP Prefix-SID attribute. This document requests IANA to assign an attribute code type (suggested value: 40) to the BGP Prefix-SID attribute from the BGP Path Attributes registry.

Currently, IANA temporarily assigned the following:

> 40 BGP Prefix-SID (TEMPORARY - registered 2015-09-30, expires 2016-09-30) [draft-ietf-idr-bgp-prefix-sid]

This document defines 3 TLVs for the BGP Prefix-SID attribute. These TLVs need to be registered with IANA. We request IANA to create a registry for BGP Prefix-SID Attribute TLVs as follows:

Under "Border Gateway Protocol (BGP) Parameters" registry, "BGP Prefix-SID TLV Types" Reference: draft-ietf-idr-bgp-prefix-sid Registration Procedure(s): Values 1-254 First Come First Served (FCFS), Value 0 and 255 reserved

Value	Type	Reference
0	Reserved	this document
1	Label-Index	this document
2	Deprecated	this document
3	Originator SRGB	this document
4-254	Unassigned	
255	Reserved	this document

This document also requests creation of the "BGP Prefix-SID Label-Index TLV Flags" registry under the "Border Gateway Protocol (BGP) Parameters" registry, Reference: draft-ietf-idr-bgp-prefix-sid. Initially, this 16 bit flags registry will be empty. Flag bits will be allocated First Come First Served (FCFS) consistent with the BGP-SID TLV Types registry.

Finally, this document requests creation of the "BGP Prefix-SID Originator SRGB TLV Flags" registry under the "Border Gateway Protocol (BGP) Parameters" registry, Reference: draft-ietf-idr-bgp-prefix-sid. Initially, this 16 bit flags registry will be empty. Flag bits will be allocated First Come First Served (FCFS) consistent with the BGP-SID TLV Types registry.

8. Manageability Considerations

This document defines a BGP attribute to address use cases such as the one described in [I-D.ietf-spring-segment-routing-msdc]. It is assumed that advertisement of the BGP Prefix-SID attribute is controlled by the operator in order to:

- Prevent undesired origination/advertisement of the BGP Prefix-SID attribute. By default, a BGP Prefix-SID attribute SHOULD NOT be attached to a prefix and advertised. Hence, BGP Prefix-SID advertisement SHOULD require explicit enablement.

- Prevent any undesired propagation of the BGP Prefix-SID attribute. By default, the BGP Prefix-SID is not advertised outside the boundary of a single SR/administrative domain which may include one or more ASes. The propagation to other ASes MUST be explicitly configured.

The deployment model described in [I-D.ietf-spring-segment-routing-msdc] assumes multiple Autonomous Systems (ASes) under a common administrative domain. For this use case, the BGP Prefix-SID advertisement is applicable to the inter-AS context, i.e., EBGP, while it is confined to a single administrative domain.

9. Security Considerations

This document introduces a BGP attribute (BGP Prefix-SID) which inherits the security considerations expressed in: [RFC4271], [RFC8277], and [I-D.ietf-spring-segment-routing].

When advertised using BGPsec as described in [RFC8205], the BGP Prefix-SID attribute doesn't impose any unique security considerations. It should be noted that the BGP Prefix-SID attribute is not protected by the BGPsec signatures.

It should be noted that, as described in Section 8, this document refers to a deployment model where all nodes are under the single administrative domain. In this context, we assume that the operator doesn't want to leak any information related to internal prefixes and topology outside of the administrative domain. The internal information includes the BGP Prefix-SID. In order to prevent such leaking, the common BGP mechanisms (filters) are applied at the boundary of the SR/administrative domain. Local BGP attribute filtering policies and mechanisms are not standardized and, consequently, beyond the scope of this document.

To prevent a Denial-of-Service (DoS) or Distributed-Denial-of-Service (DDoS) attack due to excessive BGP updates with an invalid or conflicting BGP Prefix-SID attribute, message rate-limiting as well as suppression of duplicate messages SHOULD be deployed.

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