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Segment Routing BGP Egress Peer Engineering BGP-LS Extensions
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Abstract

Segment Routing (SR) leverages source routing. A node steers a packet through a controlled set of instructions, called segments, by prepending the packet with an SR header. A segment can represent any instruction, topological or service-based. SR allows to enforce a flow through any topological path and service chain while maintaining per-flow state only at the ingress node of the SR domain.

The Segment Routing architecture can be directly applied to the MPLS dataplane with no change on the forwarding plane. It requires minor extension to the existing link-state routing protocols.

This document outline a BGP-LS extension for exporting BGP peering node topology information (including its peers, interfaces and peering ASs) in a way that is exploitable in order to compute efficient BGP Peering Engineering policies and strategies.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

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Table of Contents

1. Introduction 3
2. Segment Routing Documents 3
3. BGP Peering Segments 4
4. Link NLRI for BGP-EPE Connectivity Description 5
4.1. BGP Router ID and Member ASN 5
4.2. BGP-EPE Node Descriptors 6
4.3. Link Attributes 7
5. Peer Node and Peer Adjacency Segments 9
5.1. Peer Node Segment (Peer-Node-SID) 9
5.2. Peer Adjacency Segment (Peer-Adj-SID) 10
5.3. Peer Set Segment 11
6. Illustration 12
6.1. Reference Diagram 12
6.2. Peer Node Segment for Node D 14
6.3. Peer Node Segment for Node H 14
6.4. Peer Node Segment for Node E 14
6.5. Peer Adjacency Segment for Node E, Link 1 15
6.6. Peer Adjacency Segment for Node E, Link 2 15
7. Implementation Status 16
8. IANA Considerations 17
8.1. New BGP-LS Protocol-ID 17

8.2. Node Descriptors and Link Attribute TLVs 17
9. Manageability Considerations 18
10. Security Considerations 18
11. Contributors 18
12. Acknowledgements 18
13. References 19
13.1. Normative References 19
13.2. Informative References 19
Authors' Addresses 20

1. Introduction

Segment Routing (SR) leverages source routing. A node steers a packet through a controlled set of instructions, called segments, by prepending the packet with an SR header. A segment can represent any instruction, topological or service-based. SR allows to enforce a flow through any topological path and service chain while maintaining per-flow state only at the ingress node of the SR domain.

The Segment Routing architecture can be directly applied to the MPLS dataplane with no change on the forwarding plane. It requires minor extension to the existing link-state routing protocols.

This document outline a BGP-LS extension for exporting BGP peering node topology information (including its peers, interfaces and peering ASs) in a way that is exploitable in order to compute efficient BGP Egress Peer Engineering (BGP-EPE) policies and strategies.

This document defines new types of segments: a Peer Node segment describing the BGP session between two nodes; a Peer Adjacency Segment describing the link (one or more) that is used by the BGP session; the Peer Set Segment describing an arbitrary set of sessions or links between the local BGP node and its peers.

While an egress point topology usually refers to eBGP sessions between external peers, there's nothing in the extensions defined in this document that would prevent the use of these extensions in the context of iBGP sessions.

2. Segment Routing Documents

The main reference for this document is the SR architecture defined in [I-D.ietf-spring-segment-routing].

The Segment Routing BGP Egress Peer Engineering (BGP-EPE) architecture is described in [I-D.ietf-spring-segment-routing-central-epe].

3. BGP Peering Segments

As defined in [I-D.ietf-spring-segment-routing-central-epe], an BGP-EPE enabled Egress PE node MAY advertise segments corresponding to its attached peers. These segments are called BGP peering segments or BGP Peering SIDs. In case of eBGP, they enable the expression of source-routed inter-domain paths.

An ingress border router of an AS may compose a list of segments to steer a flow along a selected path within the AS, towards a selected egress border router C of the AS and through a specific peer. At minimum, a BGP-EPE policy applied at an ingress PE involves two segments: the Node SID of the chosen egress PE and then the BGP Peering Segment for the chosen egress PE peer or peering interface.

This document defines the BGP-EPE Peering Segments:

- Peer Node Segment (Peer-Node-SID)
- Peer Adjacency Segment (Peer-Adj-SID)
- Peer Set Segment (Peer-Set-SID)

Each BGP session MUST be described by a Peer Node Segment. The description of the BGP session MAY be augmented by additional Adjacency Segments. Finally, each Peer Node Segment and Peer Adjacency Segment MAY be part of the same group/set so to be able to group EPE resources under a common Peer-Set Segment Identifier (SID).

Therefore, when the extensions defined in this document are applied to the use case defined in [I-D.ietf-spring-segment-routing-central-epe]:

- One Peer Node Segment MUST be present.
- One or more Peer Adjacency Segments MAY be present.
- Each of the Peer Node and Peer Adjacency Segment MAY use the same Peer-Set.

While an egress point topology usually refers to eBGP sessions between external peers, there's nothing in the extensions defined in this document that would prevent the use of these extensions in the context of iBGP sessions.

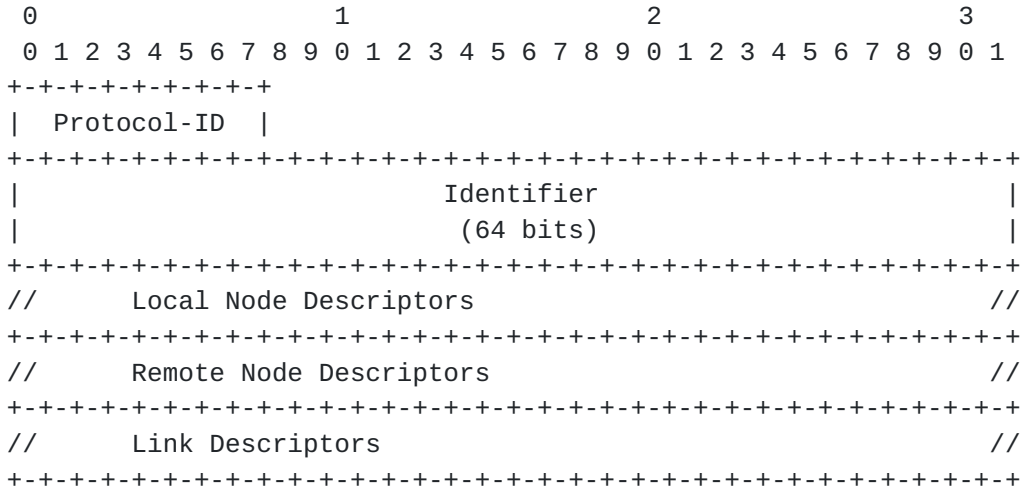
4. Link NLRI for BGP-EPE Connectivity Description

This section describes the NLRI used for describing the connectivity of the BGP Egress router. The connectivity is based on links and remote peers/ASs and therefore the existing Link-Type NLRI (defined in [RFC7752]) is used. A new Protocol ID is used: BGP (codepoint to be assigned by IANA).

The use of a new Protocol-ID allows separation and differentiation between the NLRIs carrying BGP-EPE descriptors from the NLRIs carrying IGP link-state information as defined in [RFC7752]. The Link NLRI Type uses descriptors and attributes already defined in [RFC7752] in addition to new TLVs defined in the following sections of this document.

The extensions defined in this document apply to both internal and external BGP-LS EPE advertisements.

[RFC7752] defines Link NLRI Type is as follows:



Node Descriptors and Link Descriptors are defined in [RFC7752].

4.1. BGP Router ID and Member ASN

Two new Node Descriptors Sub-TLVs are defined in this document:

- BGP Router Identifier (BGP Router-ID):

  Type: TBD2 (to be assigned by IANA from the registry "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs").

  Length: 4 octets

Value: 4 octet unsigned integer representing the BGP Identifier as defined in [RFC4271] and [RFC6286].

- Confederation Member ASN (Member-ASN)

  Type: TBD3 (to be assigned by IANA from the registry "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs").

  Length: 4 octets

  Value: 4 octet unsigned integer representing the Member ASN inside the Confederation.[RFC5065].

4.2. BGP-EPE Node Descriptors

The following Node Descriptors Sub-TLVs MUST appear in the Link NLRI as Local Node Descriptors:

- BGP Router ID, which contains the BGP Identifier of the local BGP-EPE capable node.
- Autonomous System Number, which contains the local ASN or local confederation identifier (ASN) if confederations are used.
- BGP-LS Identifier.

It has to be noted that [RFC6286] (section 2.1) requires the BGP identifier (router-id) to be unique within an Autonomous System. Therefore, the <ASN, BGP identifier> tuple is globally unique.

The following Node Descriptors Sub-TLVs MAY appear in the Link NLRI as Local Node Descriptors:

- Member-ASN, which contains the ASN of the confederation member (when BGP confederations are used).
- Node Descriptors as defined in [RFC7752].

The following Node Descriptors Sub-TLVs MUST appear in the Link NLRI as Remote Node Descriptors:

- BGP Router ID, which contains the BGP Identifier of the peer node.
- Autonomous System Number, which contains the peer ASN or the peer confederation identifier (ASN), if confederations are used.

The following Node Descriptors Sub-TLVs MAY appear in the Link NLRI as Remote Node Descriptors:

- Member-ASN, which contains the ASN of the confederation member (when BGP confederations are used).

- Node Descriptors as defined in defined in [RFC7752].

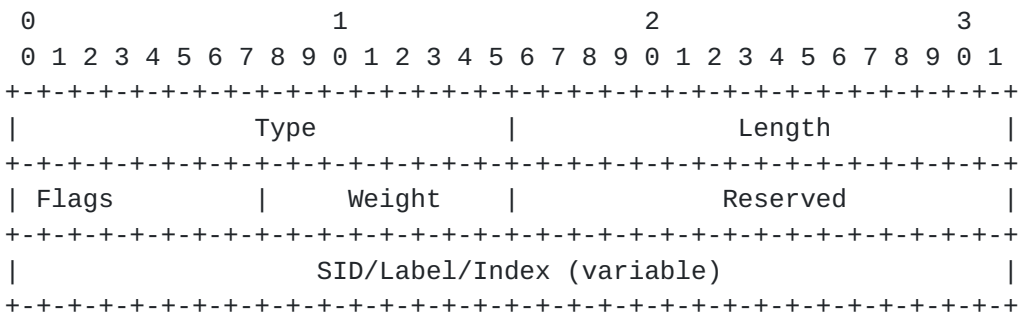
4.3. Link Attributes

The following BGP-LS Link attributes TLVs are used with the Link NLRI:

TLV Code Point	Description	Length
TBD4	Peer Node Segment Identifier (Peer-Node-SID)	variable
TBD5	Peer Adjacency Segment Identifier (Peer-Adj-SID)	variable
TBD6	Peer Set Segment Identifier (Peer-Set-SID)	variable

Figure 1: BGP-LS TLV code points for BGP-EPE

Peer-Node-SID, Peer-Adj-SID and Peer-Set-SID have all the same format defined here below:



where:

Figure 2

- Type: TBD4 or TBD5 or TBD6, to be assigned by IANA.

- Length: variable.

- Flags: following flags have been defined:

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|V|L|           |
+-+-+-+-+-+-+-+-+
```

where:

  - V-Flag: Value flag. If set, then the Adj-SID carries a value. By default the flag is SET.

  - L-Flag: Local Flag. If set, then the value/index carried by the Adj-SID has local significance. By default the flag is SET.

  - Other bits: MUST be zero when originated and ignored when received.

- Weight: 1 octet. The value represents the weight of the SID for the purpose of load balancing. An example use of the weight is described in [I-D.ietf-spring-segment-routing].

- SID/Index/Label. According to the TLV length and to the V and L flags settings, it contains either:

  - A 3 octet local label where the 20 rightmost bits are used for encoding the label value. In this case the V and L flags MUST be set.

  - A 4 octet index defining the offset in the SID/Label space advertised by this router using the encodings defined in Section 3.1. In this case V and L flags MUST be unset.

  - A 16 octet IPv6 address. In this case the V flag MUST be set. The L flag MUST be unset if the IPv6 address is globally unique.

The values of the Peer-Node-SID, Peer-Adj-SID and Peer-Set-SID Sub-TLVs SHOULD be persistent across router restart.

The Peer-Node-SID MUST be present when BGP-LS is used for the use case described in [I-D.ietf-spring-segment-routing-central-epe] and MAY be omitted for other use cases.

The Peer-Adj-SID and Peer-Set-SID SubTLVs MAY be present when BGP-LS is used for the use case described in

[I-D.ietf-spring-segment-routing-central-epe] and MAY be omitted for other use cases.

In addition, BGP-LS Nodes and Link Attributes, as defined in [RFC7752] MAY be inserted in order to advertise the characteristics of the link.

5. Peer Node and Peer Adjacency Segments

In this section the following Peer Segments are defined:

Peer Node Segment (Peer-Node-SID)

Peer Adjacency Segment (Peer-Adj-SID)

Peer Set Segment (Peer-Set-SID)

The Peer Node, Peer Adjacency and Peer Set segments can be either a local or a global segment (depending on the setting of the V and L flags defined in Figure 2. For example, when BGP-EPE is used in the context of a SR network over the IPv6 dataplane, it is likely the case that the IPv6 addresses used as SIDs will be global.

5.1. Peer Node Segment (Peer-Node-SID)

The Peer Node Segment describes the BGP session peer (neighbor). It MUST be present when describing a BGP-EPE topology as defined in [I-D.ietf-spring-segment-routing-central-epe]. The Peer Node Segment is encoded within the BGP-LS Link NLRI specified in Section 4.

The Peer Node Segment, at the BGP node advertising it, has the following semantic:

- SR header operation: NEXT (as defined in [I-D.ietf-spring-segment-routing]).
- Next-Hop: the connected peering node to which the segment is related.

The Peer Node Segment is advertised with a Link NLRI, where:

- Local Node Descriptors contains

  Local BGP Router ID of the BGP-EPE enabled egress PE.
  Local ASN.
  BGP-LS Identifier.

- Remote Node Descriptors contains

Peer BGP Router ID (i.e.: the peer BGP ID used in the BGP session).
Peer ASN.

- Link Descriptors Sub-TLVs, as defined in [RFC7752], contain the addresses used by the BGP session:
  - IPv4 Interface Address (Sub-TLV 259) contains the BGP session IPv4 local address.
  - IPv4 Neighbor Address (Sub-TLV 260) contains the BGP session IPv4 peer address.
  - IPv6 Interface Address (Sub-TLV 261) contains the BGP session IPv6 local address.
  - IPv6 Neighbor Address (Sub-TLV 262) contains the BGP session IPv6 peer address.
- Link Attribute contains the Peer-Node-SID TLV as defined in Section 4.3.
- In addition, BGP-LS Link Attributes, as defined in [RFC7752], MAY be inserted in order to advertise the characteristics of the link.

5.2. Peer Adjacency Segment (Peer-Adj-SID)

The Peer Adjacency Segment, at the BGP node advertising it, has the following semantic:

- SR header operation: NEXT (as defined in [I-D.ietf-spring-segment-routing]).
- Next-Hop: the interface peer address.

The Peer Adjacency Segment is advertised with a Link NLRI, where:

- Local Node Descriptors contains

  Local BGP Router ID of the BGP-EPE enabled egress PE.
  Local ASN.
  BGP-LS Identifier.

- Remote Node Descriptors contains

  Peer BGP Router ID (i.e.: the peer BGP ID used in the BGP session).
  Peer ASN.

- Link Descriptors Sub-TLVs, as defined in [RFC7752], MUST contain the following TLVs:
  - Link Local/Remote Identifiers (Sub-TLV 258) contains the 4-octet Link Local Identifier followed by the 4-octet value 0 indicating the Link Remote Identifier in unknown [RFC5307].
- In addition, Link Descriptors Sub-TLVs, as defined in [RFC7752], MAY contain the following TLVs:
  - IPv4 Interface Address (Sub-TLV 259) contains the address of the local interface through which the BGP session is established.
  - IPv6 Interface Address (Sub-TLV 261) contains the address of the local interface through which the BGP session is established.
  - IPv4 Neighbor Address (Sub-TLV 260) contains the IPv4 address of the peer interface used by the BGP session.
  - IPv6 Neighbor Address (Sub-TLV 262) contains the IPv6 address of the peer interface used by the BGP session.
- Link attribute used with the Peer-Adj-SID contains the TLV as defined in Section 4.3.

In addition, BGP-LS Link Attributes, as defined in [RFC7752], MAY be inserted in order to advertise the characteristics of the link.

5.3. Peer Set Segment

The Peer Adjacency Segment, at the BGP node advertising it, has the following semantic:

- SR header operation: NEXT (as defined in [I-D.ietf-spring-segment-routing]).
- Next-Hop: load balance across any connected interface to any peer in the related set.

The Peer Set Segment is advertised within a Link NLRI (describing a Peer Node Segment or a Peer Adjacency segment) as a BGP-LS attribute.

The Peer Set Attribute contains the Peer-Set-SID TLV, defined in Section 4.3 identifying the set of which the Peer Node Segment or Peer Adjacency Segment is a member.

6. Illustration

6.1. Reference Diagram

The following reference diagram is used throughout this document. The solution is illustrated for IPv4 with MPLS-based segments and the BGP-EPE topology is based on eBGP sessions between external peers.

As stated in Section 3, the solution illustrated hereafter is equally applicable to an iBGP session topology. In other words, the solution also applies to the case where C, D, H, and E are in the same AS and run iBGP sessions between each other.

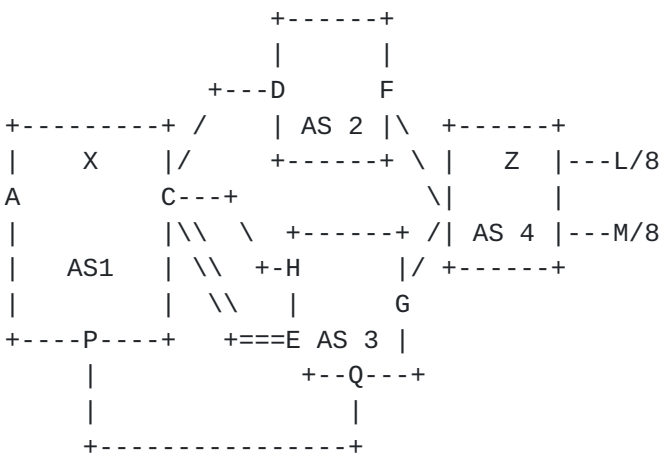


Figure 3: Reference Diagram

IPv4 addressing:

- C's IPv4 address of interface to D: 1.0.1.1/24, D's interface: 1.0.1.2/24
- C's IPv4 address of interface to H: 1.0.2.1/24, H's interface: 1.0.2.2/24
- C's IPv4 address of upper interface to E: 1.0.3.1, E's interface: 1.0.3.2/24
- C's local identifier of upper interface to E: 0.0.0.1.0.0.0.0
- C's IPv4 address of lower interface to E: 1.0.4.1/24, E's interface: 1.0.4.2/24
- C's local identifier of lower interface to E: 0.0.0.2.0.0.0.0
- Loopback of E used for eBGP multi-hop peering to C: 1.0.5.2/32

- C's loopback is 3.3.3.3/32 with SID 64

BGP Router-IDs are C, D, H and E.

- C's BGP Router-ID: 3.3.3.3
- D's BGP Router-ID: 4.4.4.4
- E's BGP Router-ID: 5.5.5.5
- H's BGP Router-ID: 6.6.6.6

C's BGP peering:

- Single-hop eBGP peering with neighbor 1.0.1.2 (D)
- Single-hop eBGP peering with neighbor 1.0.2.2 (H)
- Multi-hop eBGP peering with E on ip address 1.0.5.2 (E)

C's resolution of the multi-hop eBGP session to E:

- Static route 1.0.5.2/32 via 1.0.3.2
- Static route 1.0.5.2/32 via 1.0.4.2

Node C configuration is such that:

- A Peer Node segment (Peer-Node-SID) is allocated to each peer (D, H and E).
- An Peer Adjacency segment (Peer-Adj-SID) is defined for each recursing interface to a multi-hop peer (CE upper and lower interfaces).
- A Peer Set segment (Peer-Set-SID) is defined to include all peers in AS3 (peers H and E).

Local BGP-LS Identifier in router C is set to 10000.

The Link NLRI Type is used in order to encode C's connectivity. The Link NLRI uses the new Protocol-ID value (to be assigned by IANA)

Once the BGP-LS update is originated by C, it may be advertised to internal (iBGP) as well as external (eBGP) neighbors supporting the BGP-LS EPE extensions defined in this document.

6.2. Peer Node Segment for Node D

Descriptors:

- Local Node Descriptors (BGP Router-ID, local ASN, BGP-LS Identifier): 3.3.3.3 , AS1, 10000
- Remote Node Descriptors (BGP Router-ID, peer ASN): 4.4.4.4, AS2
- Link Descriptors (BGP session IPv4 local address, BGP session IPv4 neighbor address): 1.0.1.1, 1.0.1.2

Attributes:

- Peer-Node-SID: 1012
- Link Attributes: see section 3.3.2 of [RFC7752]

6.3. Peer Node Segment for Node H

Descriptors:

- Local Node Descriptors (BGP Router-ID, ASN, BGPLS Identifier): 3.3.3.3 , AS1, 10000
- Remote Node Descriptors (BGP Router-ID ASN): 6.6.6.6, AS3
- Link Descriptors (BGP session IPv4 local address, BGP session IPv4 peer address): 1.0.2.1, 1.0.2.2

Attributes:

- Peer-Node-SID: 1022
- Peer-Set-SID: 1060
- Link Attributes: see section 3.3.2 of [RFC7752]

6.4. Peer Node Segment for Node E

Descriptors:

- Local Node Descriptors (BGP Router-ID, ASN, BGP-LS Identifier): 3.3.3.3 , AS1, 10000
- Remote Node Descriptors (BGP Router-ID, ASN): 5.5.5.5, AS3

- Link Descriptors (BGP session IPv4 local address, BGP session IPv4 peer address): 3.3.3.3, 1.0.5.2

Attributes:

- Peer-Node-SID: 1052
- Peer-Set-SID: 1060

6.5. Peer Adjacency Segment for Node E, Link 1

Descriptors:

- Local Node Descriptors (BGP Router-ID, ASN, BGP-LS Identifier): 3.3.3.3 , AS1, 10000
- Remote Node Descriptors (BGP Router-ID, ASN): 5.5.5.5, AS3
- Link Descriptors (local interface identifier, IPv4 peer interface address): 0.0.0.1.0.0.0.0 , 1.0.3.2

Attributes:

- Peer-Adj-SID: 1032
- LinkAttributes: see section 3.3.2 of [RFC7752]

6.6. Peer Adjacency Segment for Node E, Link 2

Descriptors:

- Local Node Descriptors (BGP Router-ID, ASN, BGP-LS Identifier): 3.3.3.3 , AS1, 10000
- Remote Node Descriptors (BGP Router-ID, ASN): 5.5.5.5, AS3
- Link Descriptors (local interface identifier, IPv4 peer interface address): 0.0.0.2.0.0.0.0 , 1.0.4.2

Attributes:

- Peer-Adj-SID: 1042
- LinkAttributes: see section 3.3.2 of [RFC7752]

7. Implementation Status

Note to RFC Editor: Please remove this section prior to publication, as well as the reference to RFC 7942.

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this Internet-Draft, and is based on a proposal described in [RFC7942]. The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalog of available implementations or their features. Readers are advised to note that other implementations may exist.

According to [RFC7942], "this will allow reviewers and working groups to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit".

Several early implementations exist and will be reported in detail in a forthcoming version of this document. For purposes of early interoperability testing, when no FCFS code point was available, implementations have made use of the following values:

Codepoint	Description
7	Protocol-ID BGP
516	BGP Router ID
517	BGP Confederation Member
1101	Peer-Node-SID
1102	Peer-Adj-SID
1103	Peer-Set-SID

It will ease implementation interoperability and deployment if the value could be preserved. However, when IANA-assigned values are available, implementations will be updated to use them.

8. IANA Considerations

This document defines:

A new Protocol-ID: BGP. The codepoint is from the "BGP-LS Protocol-IDs" registry.

Two new TLVs: BGP-Router-ID and BGP Confederation Member. The codepoints are in the "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs" registry.

Three new BGP-LS Attribute TLVs: Peer-Node-SID, Peer-Adj-SID and Peer-Set-SID. The codepoints are in the "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs" registry.

8.1. New BGP-LS Protocol-ID

This document defines a new value in the registry "BGP-LS Protocol-IDs":

Codepoint	Description
TBD1	BGP

8.2. Node Descriptors and Link Attribute TLVs

This document defines 5 new TLVs in the registry "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs":

- Two new node descriptor TLVs
- Three new link attribute TLVs

All the new 5 codepoints are in the same registry: "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs". However, the registry is organized in ranges (node descriptors, link descriptors, node attributes, link attributes). The allocation should be done accordingly.

The following new Node Descriptors TLVs are defined:

Codepoint	Description
TBD2	BGP Router ID
TBD3	BGP Confederation Member

The following new Link Attribute TLVs are defined:

Codepoint	Description
TBD4	Peer-Node-SID
TBD5	Peer-Adj-SID
TBD6	Peer-Set-SID

9. Manageability Considerations

TBD

10. Security Considerations

[RFC7752] defines BGP-LS NLRIs to which the extensions defined in this document apply.

The Security Section of [RFC7752] also applies to:

- New Node Descriptors Sub-TLVs: BGP-Router-ID and BGP-Confederation-Member;
- New BGP-LS Attributes TLVs: Peer-Node-SID, Peer-Adj-SID and Peer-Set-SID.

11. Contributors

Acee Lindem gave a substantial contribution to this document.

12. Acknowledgements

The authors would like to thank Jakob Heitz, Howard Yang, Hannes Gredler, Peter Psenak, Ketan Jivan Talaulikar, and Arjun Sreekantiah for their feedback and comments.

13. References

13.1. Normative References

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