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# BGP-LS Extension for Inter-AS Topology Retrieval
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## Abstract

This document specifies the procedure for distributing Border Gateway Protocol-Link State (BGP-LS) key parameters for inter-domain links between two Autonomous Systems (ASes). It defines a new type within the BGP-LS Network Layer Reachability Information (NLRI) for a Stub Link, as well as three new type-length-values (TLVs) for the BGP-LS Stub Link descriptor. These BGP-LS extensions enable Software-Defined Networking (SDN) controllers to retrieve network topology across inter-AS environments.

These extensions and procedures allow network operators to collect inter-domain interconnect information and automatically compute the end-to-end network topology using information provided by the BGP-LS protocol.

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## 1. Introduction

BGP-LS [RFC9552] describes the use of BGP protocol for advertisement of the Link-State topology information. It enables applications such as a SDN controllers to collect the underlay network topology. [RFC9552] covers the advertisement of topology information from within Interior Gateway Protocol (IGP) domain. If the network has more than one IGP domain, and these domains interconnect with each other via inter-AS links, there is no mechanism within the current BGP-LS to advertise the interconnect topology information.

[RFC9086] defines extensions for exporting BGP peering node topology information (including peers, interfaces, and peering ASes) in a way that is used to compute efficient BGP Peering Engineering policies and strategies. This information can also be used to compute interconnection topology among different IGP domains, but it requires every border router to run the BGP-LS protocol and report such information to SDN controllers. Considering there will be several border routers on the network boundary, such solution restricts its deployment flexibility.

This document defines the Stub Link NLRI and some new TLVs for BGP-LS to cover scenarios where a SDN controller needs to get the interconnection topology information between different AS domains when sourced from IGPs.

## 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. Terminology

The following terms are defined in this document:

* IDCs: Internet Data Centers

* MAN: Metro-Area-Network

* SDN: Software Definition Network

## 4. Inter-AS Domain Scenarios

Figure 1 illustrates the multi-domain scenarios discussed in this document. Typically, the SDN Controller can retrieve the topology of IGP A and IGP B individually via the BGP-LS protocol, but it cannot obtain topology connection information between these two IGP domains, as IGP protocols are generally not run on the inter-AS links.

In Figure 1, S2(in IGP domain A) and T1(in IGP domain B) are connected to the IP SDN Controller via BGP-LS, but they can only report the topology information among the IGP A and IGP B themselves, and can't report the inter-as topology information among them because there is no IGP protocol runs on the inter-AS links. The border routers, SB1/SB3 in IGP A and TB2/TB4 in IGP B know the inter-AS links among them, and can advertise such information via underlying OSPF [RFC5392] or IS-IS [RFC9346], but there is no place in current BGP-LS protocol to transfer such information.

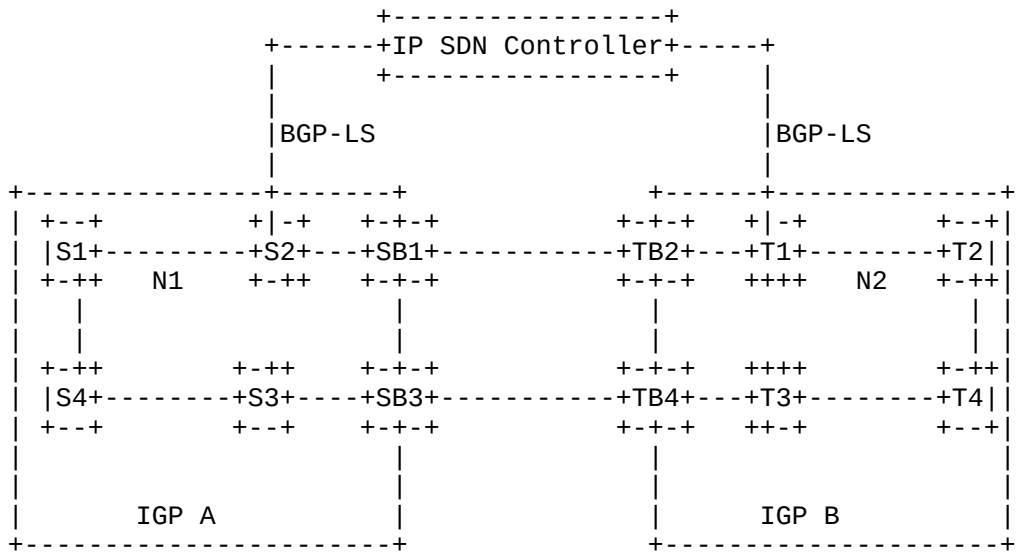


Figure 1: Inter-AS Domain Scenarios

## 5. Stub Link NLRI

[RFC9552] defines four NLRI types (Node, Link, IPv4 Topology Prefix, and IPv6 Topology Prefix) to transfer the topology and prefix information. For inter-AS link, as the two ends of the link belong in different IGP domains and the link does not run an IGP protocol, it is not appropriate to advertise their information within the existing NLRI types listed above.

This document defines a new NLRI type 7, see__Section 9) within the BGP-LS NLRI, referred to as the Stub Link NLRI. The Stub Link NLRI is encoded in the format shown in Figure 2 as explained below:

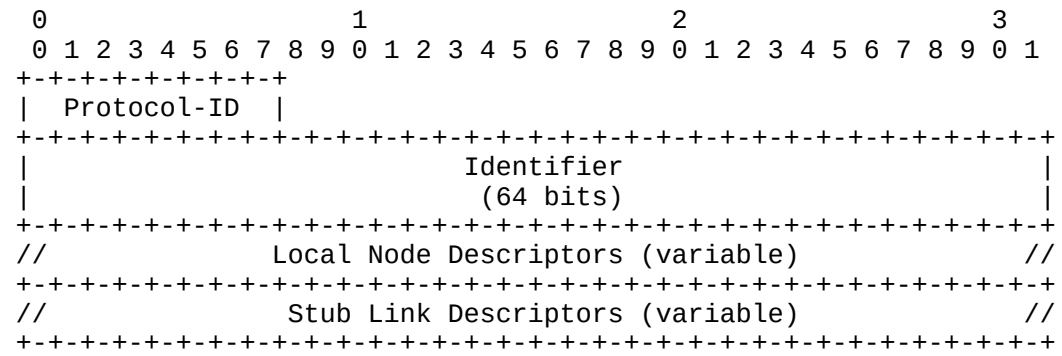


Figure 2: Stub Link NLRI Format

This document specifies the advertisement of Inter-AS Links using the Stub Link NLRI when originating the information from the underlying OSPF [RFC5392] and IS-IS [RFC9346] advertisements.

This section describes the encoding of the Stub Link NLRI while the more detailed procedures for sourcing of this information from the underlying IGP are described in Section 7.

The "Protocol-ID" is set to the value indicating the source protocol of the stub link information, as specified in [RFC9552] Section 5.2. As the information is sourced from OSPF or IS-IS, the value MUST correspond to one of IGP values as specified in [RFC9552].

The semantics of "Identifier" field are the same as defined in [RFC9552] and will be set to a value that is identical to the "Identifier" value of the IGP domain associated with the ASBR of the inter-AS link. Therefore, the "Identifier" values for the two half-links (refer section 5.2.2 of [RFC9552]) of the inter-AS link could be different depending on the configuration of Identifiers for the two IGP domains.

The "Local Node Descriptors" field is encoded using the TLV 256 defined in section 5.2.1.2 of [RFC9552] to identify the ASBR associated with the specific half-link of the inter-AS link. The following TLVs MUST be included as the Local Node Descriptors:

- Autonomous System (TLV 512) [RFC9552].

- OSPF Area-ID (TLV 514) [RFC9552] to be included only in the case of OSPF, when the Inter-AS TE LSA from which information is sourced is being flooded with an area-scope. It is not included when the LSA is flooded with AS-scope.

- IGP Router ID (TLV 515) encoded for either OSPF or IS-IS, depending on the source protocol as specified in section 5.2.1.4 of [RFC9552].

- One or both of IPv4 and IPv6 Router-ID of the ASBR using TLV 1028 and/or 1029 [RFC9552], depending on whether the ASBR is configured with one or both of the IPv4 and IPv6 TE Router-IDs. (Note: while [RFC9552] introduced these TLVs for use in the BGP-LS attribute, this document also leverages the same TLVs for use in the NLRI.)

Stub Link Descriptors are encoded as TLVs that identify the specific half-link of the inter-AS link. Section 6 of this document introduces the TLVs that MUST be included as the Stub Link Descriptors:

- Remote AS Number (TLV 270), and

- One or both of IPv4 and IPv6 Remote ASBR ID using TLV 271 and/or TLV 272, depending on whether the Remote ASBR is configured with one or both of the IPv4 and IPv6 TE Router-IDs.

Additionally, the following TLVs MUST be included as Stub Link Descriptors if they are being advertised in the underlying IGP advertisement of the inter-AS link as they help identify individual links when there are more than one inter-AS links between two ASBRs.

- Link Local/Remote Identifiers (TLV 258) [RFC9552]

- IPv4 Interface Address (TLV 259) [RFC9552]

- IPv4 Neighbor Address (TLV 260) [RFC9552]

- IPv6 Interface Address (TLV 261) [RFC9552]

- IPv6 Neighbor Address (TLV 262) [RFC9552]

Use of any other TLVs as Local Node Descriptors or Stub Link Descriptors may cause challenges in the correlation of the two Stub Link NLRI half-links when the BGP-LS Producer implementations vary.

## 6. Inter-AS Stub Link Descriptor TLVs

This document introduces three TLVs for inclusion as Stub Link Descriptors within the Stub Link NLRI for the advertisement of inter-AS link information via BGP-LS.

| TLV Code Point | Description | IS-IS/OSPF TLV /Sub-TLV | Reference (RFC/Section) |
|---|---|---|---|
| 270 | Remote AS Number | 24/21 | [RFC9346]/3.4.1 |
| | | | [RFC5392]/3.3.1 |
| 271 | IPv4 Remote ASBR ID | 25/22 | [RFC9346]/3.4.2 |
| | | | [RFC5392]/3.3.2 |
| 272 | IPv6 Remote ASBR ID | 26/24 | [RFC9346]/3.4.3 |
| | | | [RFC5392]/3.3.3 |

Figure 3: Stub Link Descriptor TLVs

The encoding of these TLVs are aligned with the corresponding advertisements in [RFC9346] and [RFC5392], which keeps the BGP-LS protocol agnostic to the underly protocol.

## 6.1. Remote AS Number TLV

The Remote AS Number TLV specifies the AS number of the neighboring AS to which the advertised link connects.

The Remote AS Number TLV is TLV Type 270 and is 4 octets in length. Its format is as follows:

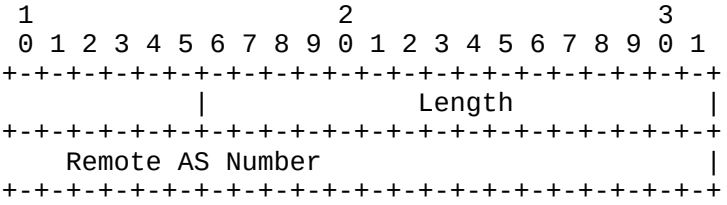


Figure 4: Remote AS Number TLV Format

The Remote AS Number field has 4 octets. When only 2 octets are used for the AS number (for example, when such information is advertised from OSPF), the left (high-order) 2 octets MUST be set to 0.

## 6.2. IPv4 Remote ASBR ID

The IPv4 Remote ASBR ID TLV specifies the IPv4 identifier of the remote ASBR to which the advertised inter-AS link connects. This can be any stable, routable IPv4 address of the remote ASBR. The use of the TE Router ID, as specified in the Traffic Engineering Router ID TLV [RFC9346] is RECOMMENDED.

The IPv4 Remote ASBR ID TLV is TLV Type 271 and is 4 octets in length. Its format is as follows:

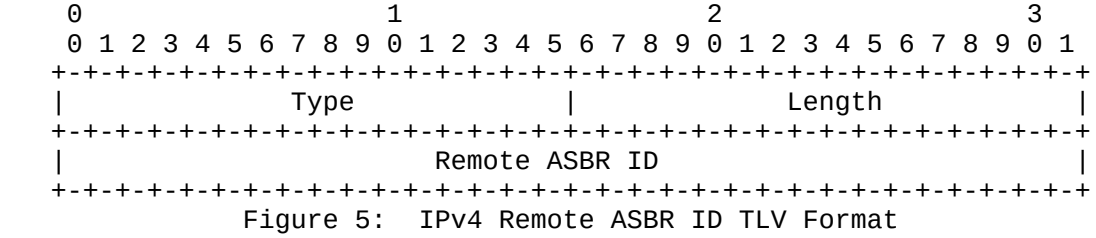


Figure 5: IPv4 Remote ASBR ID TLV Format

## 6.3. IPv6 Remote ASBR ID

The IPv6 Remote ASBR ID TLV specifies the IPv6 identifier of the remote ASBR to which the advertised inter-AS link connects. This can be any stable, routable IPv6 address of the remote ASBR. The use of the TE Router ID, as specified in the IPv6 Traffic Engineering Router ID TLV [RFC9346] is RECOMMENDED.

The IPv6 Remote ASBR ID TLV is TLV Type 272 and is 16 octets in length. Its format is as follows:

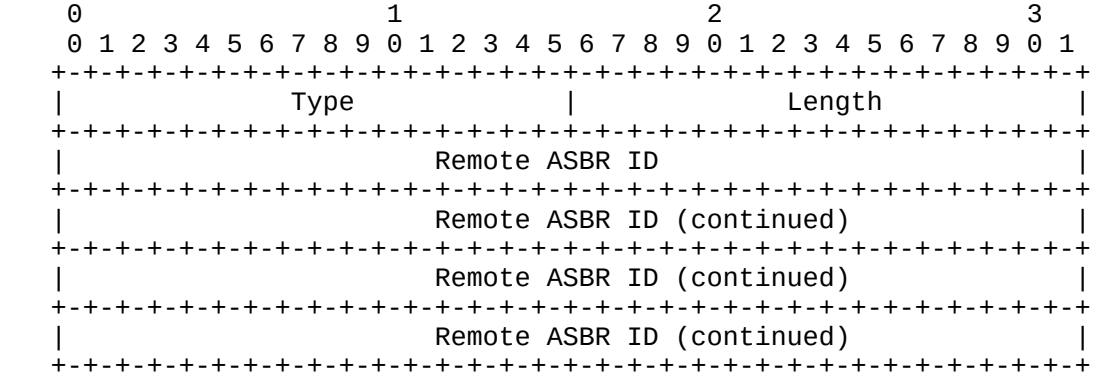


Figure 6: IPv6 Remote ASBR ID TLV Format

The IPv6 Remote ASBR ID TLV MUST be included if the neighboring ASBR has an IPv6 address. If the neighboring ASBR does not have an IPv6 address, the IPv4 Remote ASBR ID TLV MUST be included instead. Both an IPv4 Remote ASBR ID TLV and an IPv6 Remote ASBR ID TLV MAY be present in an inter-AS Stub Link NLRI.

# 7. Advertisement of IGP Information for Inter-AS Links

Advertisement of Inter-AS Links along with their TE information is done is done in IGPs as follows:

- In OSPFv2 via the Inter-AS-TE-v2 LSA [RFC5392]

- In OSPFv3 via the Inter-AS-TE-v3 LSA[RFC5392]

- In IS-IS via the Inter-AS Reachability Information TLV (TLV 141) [RFC9346]

When advertising these Inter-AS Links from the IGPs into BGP-LS as Stub Links, the sourcing of information for the Stub Link NLRI except for the Stub Link Descriptors follows the same procedures as specified in [RFC9552]. The information about the Remote AS Number and the IPv4/IPv6 Remote ASBR IDs specified in Section 6 are derived from the Remote AS Number and IPv4/IPv6 Remote ASBR ID TLVs specified for OSPF and IS-IS in [RFC5392] and [RFC9346] respectively. The rest of the Stub Descriptor TLVs of the Stub NLRI are sourced from the base OSPF/ISIS TE TLVs that were originally introduced for normal IGP links and which are also encoded for the inter-AS TE links as specified in [RFC5392] and [RFC9346]; their procedures are therefore same as in [RFC9552].

The OSPF/ISIS Inter-AS Link advertisements also include various link properties (e.g., TE metric, Admin Groups, SRLGs, etc.) which are encoded using the same TLVs as for normal IGP links. These link properties are advertised using their corresponding BGP-LS TLVs as specified in [RFC9552] and other BGP-LS extensions in the BGP-LS Attribute associated with the Stub Link NLRI of that specific link.

## 8. Security Considerations

BGP-LS security is specified in [RFC9552]. This extension to BGP-LS focuses on scenarios where a single entity-operated network includes multiple IGP domains composed of its backbone network, several Metro-Area Networks (MANs), and Internet Data Centers (IDCs). The configuration of these networks, operated by a single administrative entity, creates a "walled garden". Within this single administrative domain, the network operator needs to monitor and engineer traffic flows traversing a network that spans multiple Autonomous Systems (ASes). The network operator can obtain this inter-AS topology information via the procedure described in this document.

A single administrative domain consisting of two ASes that passes information about Stub Link characteristics does not cause issues within a "walled garden". However, the Stub Link NLRI and its characteristics (Link/Local Identifier, IPv4 Interface Address, IPv4 Neighbor Address, IPv6 Interface Address, IPv6 Neighbor Address, Multi-Topology Identifier, Remote-AS Number, IPv4 Remote ASBR ID, and IPv6 Remote ASBR ID) constitute critical network information. As such, operators SHOULD handle this critical information in a manner that restricts it to the walled garden.

## 9. IANA Considerations

This document requests IANA to update the allocated codepoints from under the "Border Gateway Protocol - Link State (BGP-LS) Parameters" registry group as follows:

### 9.1. New BGP-LS NLRI type

IANA has allocated codepoint for the Stub Link NLRI type from the "BGP-LS NLRI Types" registry in the “Border Gateway Protocol Link State (BGP-LS) Parameter” Group:

| Type | NLRI Type | Reference |
|---|---|---|
| 7 | Stub Link NLRI | This document |

Figure 7: Stub Link NLRI Codepoint

### 9.2. New Stub Link Descriptors

IANA has allocated codepoints for the following TLVs from "BGP-LS NLRI and Attribute TLVs" registry in the “Border Gateway Protocol Link State (BGP-LS) Parameter” Group:

| TLV Code Point | Description | Reference |
|---|---|---|
| 270 | Remote AS Number | This document |
| 271 | IPv4 Remote ASBR ID | This document |
| 272 | IPv6 Remote ASBR ID | This document |

Figure 8: BGP-LS Link Descriptors TLV

## 10. Acknowledgement

The author would like to thank Susan Hares, Acee Lindem, Jie Dong, Shaowen Ma, Jeff Tantsura and Dhruv Dhody for their valuable comments and suggestions.

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[RFC9552] Talaulikar, K., Ed., "Distribution of Link-State and Traffic Engineering Information Using BGP", RFC 9552, DOI 10.17487/RFC9552, December 2023, <https://www.rfc-editor.org/info/rfc9552>.

## 11.2. Informative References

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