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Applicability of Border Gateway Protocol - Link State (BGP-LS) with Multi-Topology (MT) for Segment Routing based Network Resource Partitions (NRPs)

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Abstract

When Segment Routing (SR) is used for building Network Resource Partitions (NRPs), each NRP can be allocated with a group of Segment Identifiers (SIDs) to identify the topology and resource attributes of network segments in the NRP. This document describes how BGP-Link State (BGP-LS) with Multi-Topology (MT) can be used to distribute the information of SR based NRPs to the network controller when each NRP is associated with a separate logical network topology identified by a Multi-Topology ID (MT-ID).

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1. Introduction

[RFC9543] discusses the general framework, components, and interfaces for requesting and operating network slices using IETF technologies. [RFC9543] also introduces the concept of the Network Resource Partition (NRP), which is defined as a subset of the buffer/queuing/scheduling resources and associated policies on each of a connected set of links in an underlay network. An NRP can be associated with a logical network topology to select or specify the set of links and nodes involved. [RFC9732] specifies the framework of NRP-based enhanced VPNs and describes the candidate component technologies in different network planes and network layers. An NRP could be used as the underlay to meet the requirement of one or a group of network slice or enhanced VPN services. The mechanism of enforcing NRP resource allocation and the mechanism of mapping one or group of enhanced VPN services to a specific NRP is outside the scope of this document.

[I-D.ietf-spring-resource-aware-segments] introduces resource awareness to Segment Routing (SR) [RFC8402]. As described in [I-D.ietf-spring-sr-for-enhanced-vpn], a group of resource-aware SIDs can be used to build SR-based NRPs with the required network topology and network resource attributes. The group of resource-aware SR SIDs together with the associated topology and resource attributes of an NRP need to be distributed in the network using IGP, and BGP-Link State (BGP-LS) [RFC9552] can be used to advertise the SR SIDs and the resource related Traffic Engineering (TE) attributes (e.g., link bandwidth) of NRPs in each IGP area or AS to the network controller.

In some network scenarios, the required number of NRPs could be small, each NRP can be associated with an separate logical topology, i.e., there is 1:1 mapping between an NRP and an Multi-Topology (MT) ID, and a set of dedicated or shared network resources is allocated to the NRP. [I-D.ietf-lsr-isis-sr-vtn-mt] describes how IS-IS Multi-Topology (MT) [RFC5120] can be used to advertise an independent topology and the associated SR SIDs, together with the resource related TE attributes for each SR based NRP in the network. This document describes the how BGP-LS with MT can be used distribute the information of SR based NRPs to the network controller.

2. Advertisement of Topology Information for SR-based NRP

[I-D.ietf-lsr-isis-sr-vtn-mt] describes the IS-IS Multi-Topology based mechanisms to distribute the topology and the SR SIDs associated with SR based NRPs. This section describes the corresponding BGP-LS mechanism to distribute both the intra-domain and inter-domain topology information and the SR SIDs of SR based NRPs. It is considered that in each domain, one data plane mechanism is used for one NRP, while for inter-domain SR based NRPs, different data plane mechanisms (either SR-MPLS or SRv6) may be used in different domains. For the inter-domain SR based NRPs, the involved network domains should be under a common administration, or they belong to the same trusted domain as specified in section 8 of [RFC8402].

2.1. Intra-domain Topology Advertisement

Section 5.2.2.1 of [RFC9552] defines the Multi-Topology Identifier (MT-ID) TLV (Type 263), which can contain one or more Multi-Topology Identifiers for a link, node, or prefix. The MT-ID TLV may be included as a Link Descriptor, as a Prefix Descriptor, or in the BGP-LS Attribute of a Node Network Layer Reachability Information (NLRI), the detailed rules of the usage of MT-ID TLV in BGP-LS is described in section 5.2.2.1 of [RFC9552] .

[RFC9085] defines the BGP-LS extensions to carry the SR-MPLS information using TLVs of BGP-LS Attribute. When Multi-Topology is used with the SR-MPLS data plane, topology-specific Prefix-SIDs and topology-specific Adjacency Segment Identifiers (Adj-SIDs) can be carried in the BGP-LS Attribute associated with the Prefix NLRI and

Link NLRI respectively, the MT-ID TLV carried in the prefix descriptor or link descriptor [RFC9552] can be used to identify the corresponding topology of the SIDs.

[RFC9514] defines the BGP-LS extensions to advertise Segment Routing over IPv6 (SRv6) information along with their functions and attributes. When Multi-Topology is used with the SRv6 data plane, the SRv6 Locator TLV is carried in the BGP-LS Attribute associated with the Prefix NLRI, the MT-ID TLV can be carried as a Prefix Descriptor to identify the corresponding topology of the SRv6 Locator. The SRv6 End.X SIDs are carried in the BGP-LS Attribute associated with the Link NLRI, the MT-ID TLV can be carried in the link descriptor to identify the corresponding topology of the End.X SIDs. The SRv6 SID NLRI is defined to advertise other types of SRv6 SIDs, in which the SRv6 SID descriptors can include the MT-ID TLV so as to advertise topology-specific SRv6 SIDs.

2.2. Inter-Domain Topology Advertisement

[RFC9086] defines the BGP-LS extensions for BGP Egress Peer Engineering (EPE) with SR-MPLS. The BGP-LS extensions for Egress Peer Engineering with SRv6 are specified in [RFC9514]. Such information could be used by a network controller for the collection of inter-domain topology and SR SID information, which can be used for the computation and instantiation of inter-AS SR-TE paths.

In some network scenarios, for instance, an operator’s network consists of multiple network parts, such as metro area networks, backbone networks, or data center networks, each part being a different AS. Thus there is a need to create NRPs which span multiple ASes. The inter-domain NRPs may have different inter-domain logical topology, and may be associated with different subsets of network resources in each domain and also on the inter-domain links. To build multi-domain SR based NRPs, the inter-domain connectivity and the BGP peering SIDs associated with each logical topology on the inter-domain links need to be advertised. This section describes the applicability of multi-topology for the advertisement of inter-domain topology and the associated SR SIDs using BGP-LS. It does not introduce multi-topology into the operation of BGP sessions on the inter-domain links.

When an MT-ID is configured consistently in multiple domains covered by an NRP, the MT-ID may also be carried in the link NLRI of the inter-domain links for the advertisement of inter-domain logical topology and the topology-specific BGP peering SIDs. This can be achieved with the combination of existing mechanisms as defined in [RFC9552][RFC9086] and [RFC9514].

Depending on the different scenarios of inter-domain SR based NRPs, the approach for the inter-domain topology advertisement can be one of the following:

* One External BGP (EBGP) session between two ASes can be established over multiple underlying links. In this case, different underlying links may be used for different inter-domain NRPs. In another similar case, the EBGP session is established over a single physical link, while the network resource (e.g., bandwidth) on this link is partitioned into multiple pieces, each of which is instantiated as a logical sub-interface. Each underlying physical or logical link is associated with the MT-ID of the NRP, and different BGP Peer-Adj-SIDs or SRv6 End.X SIDs need to be allocated to each underlying physical or logical link. The association between the underlying physical of logical link and the corresponding MT-ID, together with the BGP Peer-Adj-SIDs or SRv6 End.X SID need to be advertised by the ASBR to the network controller.

* For inter-domain connection between two ASes, multiple EBGP sessions can be established between different sets of peering ASBRs. It is possible that some of these BGP peers are only used for one inter-domain NRP, while some other BGP peers are used for another inter-domain NRP. In this case, different BGP Peer Node SIDs can be allocated to steer traffic to a specific peer within an inter-domain NRP. The association between the link of the BGP peering session and the corresponding MT-ID, together with the BGP Peer Node SIDs need to be advertised by the ASBR to the network controller.

* At the level inter-AS topology, different inter-domain NRPs may have different inter-AS connectivity. In this case, different BGP Peer Set SIDs may be allocated to represent a groups of BGP peers which can be used for load-balancing within each inter-domain NRP. The BGP Peer Set SIDs may be advertised in the BGP-LS attributes of the link NLRI which carries the MT-ID of the corresponding NRP.

In network scenarios where consistent allocation of MT-ID among multiple domains can not be achieved, the MT-ID advertised by the two peering ASBRs to the controller for the same inter-domain link could be different. Some mapping mechanism may be needed by the controller to match the MT-IDs of an inter-domain link in two directions, and concatenate the inter-domain topology of the NRP. The detailed mechanism is out of the scope of this document.

3. Advertisement of Resource related TE Attribute for SR-based NRP

[I-D.ietf-lsr-isis-sr-vtn-mt] describes the applicability of IS-IS multi-topology for the advertisement of resource related TE attributes associated with each SR based NRP. This section describes the applicability of BGP-LS with multi-topology for reporting resource related TE attributes of each SR based NRP to network controllers.

The information of the network resources attributes associated with a link of an NRP can be specified by carrying the corresponding TE Link attribute TLVs in BGP-LS Attribute [RFC9552], with the associated MT-ID carried in the corresponding Link NLRI.

For example, the amount of bandwidth resource allocated to an NRP on a link can be advertised by carrying the Maximum Link Bandwidth sub-TLV in the BGP-LS Attribute associated with the Link NLRI which carries the MT-ID of the NRP. The bandwidth allocated to an NRP can be exclusive for traffic carried by the corresponding NRP. The advertisement of other topology-specific TE attributes in BGP-LS for NRP is for further study. The receiving BGP-LS speaker should be prepared to receive any TE attributes in BGP-LS Attribute with the associated MT-ID carried in the corresponding Link NLRI.

4. Scalability Considerations

The mechanism described in this document assumes that each NRP is associated with an independent topology, and for the inter-domain NRPs, the MT-IDs used in the involved domains are consistent, so that the associated MT-ID can be used to identify the NRP in the control plane. Reusing MT-ID can avoid introducing new mechanisms with similar functionality in the control plane, while it also has some limitations. For example, even if multiple NRPs share the same topology, each NRP still need to be identified using a unique MT-ID in the control plane. Thus independent path computation needs be executed for each NRP. The number of NRPs supported in a network may be dependent on the number of topologies supported, which is related to both the number of topologies supported in the protocol and the control plane overhead which the network could afford. Since no new control protocol extension is required, the mechanism described in this document is considered useful for network scenarios in which the required number of NRPs is small (e.g., less than 10). For network scenarios where the number of required NRPs is large, more scalable solutions would be needed which may require further protocol extensions and enhancements. A detailed analysis about the NRP scalability and the possible optimizations for supporting a large number of NRPs are described in [I-D.ietf-teas-nrp-scalability].

5. Security Considerations

The security considerations in [RFC9552] [RFC9085] and [RFC9514] apply to this document.

This document introduces no additional security vulnerabilities to BGP-LS. The mechanism proposed in this document is subject to the same vulnerabilities as any other protocol that relies on BGP-LS.

6. IANA Considerations

This document does not request any IANA actions.

7. Acknowledgments

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