Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: October 29, 2020

S. Previdi
K. Talaulikar, Ed.
Cisco Systems, Inc.
J. Dong, Ed.
M. Chen
Huawei Technologies
H. Gredler
RtBrick Inc.
J. Tantsura
Apstra

April 27, 2020

Distribution of Traffic Engineering (TE) Policies and State using BGP-LS
draft-ietf-idr-te-lsp-distribution-13

Abstract

This document describes a mechanism to collect the Traffic Engineering and Policy information that is locally available in a node and advertise it into BGP Link State (BGP-LS) updates. Such information can be used by external components for path computation, re-optimization, service placement, network visualization, etc.

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 October 29, 2020.

Copyright Notice

Copyright (c) 2020 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 Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1. Introduction 3
1.1. Requirements Language 5
2. Carrying TE Policy Information in BGP 5
3. TE Policy NLRI 6
4. TE Policy Descriptors 7
4.1. Tunnel Identifier (Tunnel ID) 8
4.2. LSP Identifier (LSP ID) 8
4.3. IPv4/IPv6 Tunnel Head-End Address 9
4.4. IPv4/IPv6 Tunnel Tail-End Address 9
4.5. SR Policy Candidate Path Descriptor 10
4.6. Local MPLS Cross Connect 11
4.6.1. MPLS Cross Connect Interface 13
4.6.2. MPLS Cross Connect FEC 14
5. MPLS-TE Policy State TLV 15
5.1. RSVP Objects 16
5.2. PCEP Objects 17
6. SR Policy State TLVs 18
6.1. SR Binding SID 18
6.2. SR Candidate Path State 20
6.3. SR Candidate Path Name 22
6.4. SR Candidate Path Constraints 22
6.4.1. SR Affinity Constraint 24
6.4.2. SR SRLG Constraint 25
6.4.3. SR Bandwidth Constraint 26
6.4.4. SR Disjoint Group Constraint 26
6.5. SR Segment List 28
6.6. SR Segment 31
6.6.1. Segment Descriptors 32
6.7. SR Segment List Metric 39
7. Procedures 41
8. Manageability Considerations 41
9. IANA Considerations 42
9.1. BGP-LS NLRI-Types 42
9.2. BGP-LS Protocol-IDs 42
9.3. BGP-LS TLVs 42
9.4. BGP-LS SR Policy Protocol Origin 43

9.5. BGP-LS TE State Object Origin 44
9.6. BGP-LS TE State Address Family 44
9.7. BGP-LS SR Segment Descriptors 44
9.8. BGP-LS Metric Type 45
10. Security Considerations 45
11. Contributors 46
12. Acknowledgements 46
13. References 46
13.1. Normative References 46
13.2. Informative References 48
Authors' Addresses 49

1. Introduction

In many network environments, traffic engineering (TE) policies are instantiated into various forms:

- MPLS Traffic Engineering Label Switched Paths (TE-LSPs).
- IP based tunnels (IP in IP, GRE, etc).
- Segment Routing (SR) Policies as defined in [I-D.ietf-spring-segment-routing-policy]
- Local MPLS cross-connect configuration

All this information can be grouped into the same term: TE Policies. In the rest of this document we refer to TE Policies as the set of information related to the various instantiation of polices: MPLS TE LSPs, IP tunnels (IPv4 or IPv6), SR Policies, etc.

TE Polices are generally instantiated at the head-end and are based on either local configuration or controller based programming of the node using various APIs and protocols, e.g., PCEP or BGP.

In many network environments, the configuration and state of each TE Policy that is available in the network is required by a controller which allows the network operator to optimize several functions and operations through the use of a controller aware of both topology and state information.

One example of a controller is the stateful Path Computation Element (PCE) [RFC8231], which could provide benefits in path reoptimization. While some extensions are proposed in Path Computation Element Communication Protocol (PCEP) for the Path Computation Clients (PCCs) to report the LSP states to the PCE, this mechanism may not be applicable in a management-based PCE architecture as specified in section 5.5 of [RFC4655]. As illustrated in the figure below, the

PCC is not an LSR in the routing domain, thus the head-end nodes of the TE-LSPs may not implement the PCEP protocol. In this case a general mechanism to collect the TE-LSP states from the ingress LERs is needed. This document proposes an TE Policy state collection mechanism complementary to the mechanism defined in [RFC8231].

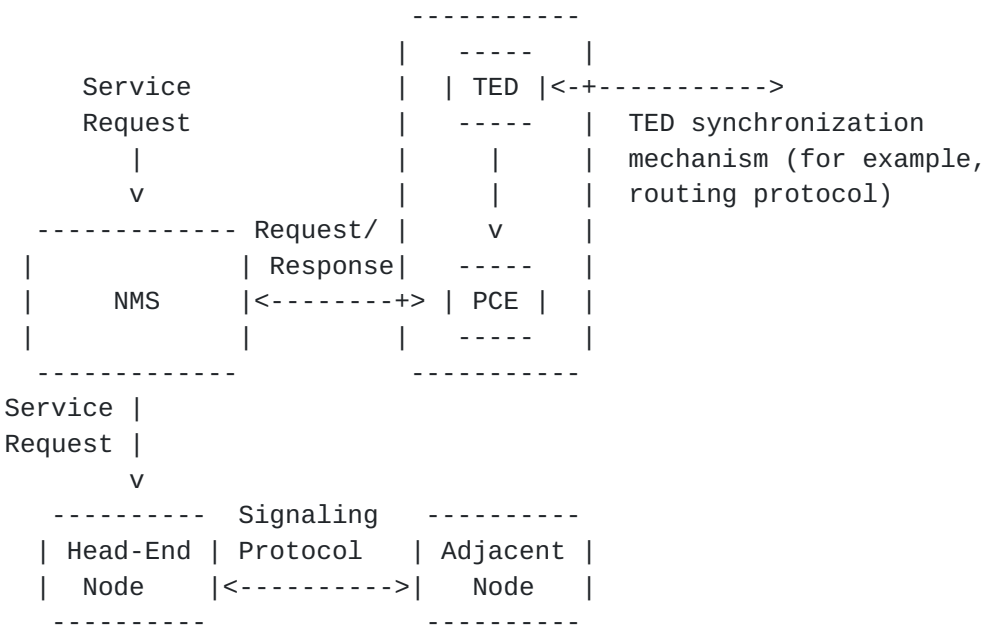


Figure 1. Management-Based PCE Usage

In networks with composite PCE nodes as specified in section 5.1 of [RFC4655], PCE is implemented on several routers in the network, and the PCCs in the network can use the mechanism described in [RFC8231] to report the TE Policy information to the PCE nodes. An external component may also need to collect the TE Policy information from all the PCEs in the network to obtain a global view of the LSP state in the network.

In multi-area or multi-AS scenarios, each area or AS can have a child PCE to collect the TE Policies in its own domain, in addition, a parent PCE needs to collect TE Policy information from multiple child PCEs to obtain a global view of LSPs inside and across the domains involved.

In another network scenario, a centralized controller is used for service placement. Obtaining the TE Policy state information is quite important for making appropriate service placement decisions with the purpose to both meet the application's requirements and utilize network resources efficiently.

The Network Management System (NMS) may need to provide global visibility of the TE Policies in the network as part of the network visualization function.

BGP has been extended to distribute link-state and traffic engineering information to external components [RFC7752]. Using the same protocol to collect Traffic Engineering Policy and state information is desirable for these external components since this avoids introducing multiple protocols for network information collection. This document describes a mechanism to distribute traffic engineering policy information (MPLS, SR, IPv4 and IPv6) to external components using BGP-LS.

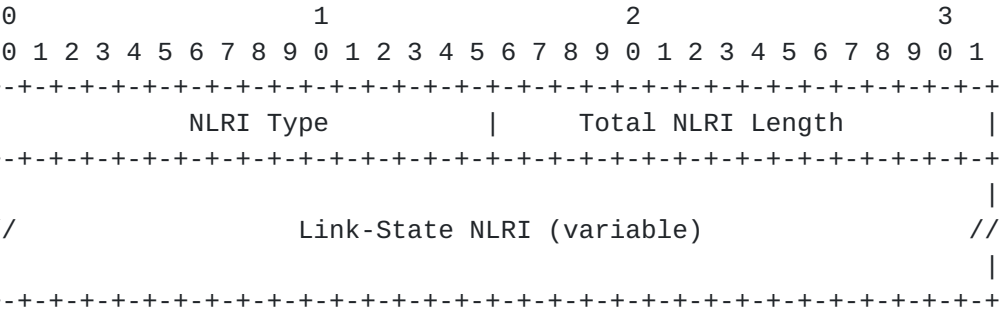
1.1. Requirements Language

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.

2. Carrying TE Policy Information in BGP

TE Policy information is advertised in BGP UPDATE messages using the MP_REACH_NLRI and MP_UNREACH_NLRI attributes [RFC4760]. The "Link-State NLRI" defined in [RFC7752] is extended to carry the TE Policy information. BGP speakers that wish to exchange TE Policy information MUST use the BGP Multiprotocol Extensions Capability Code (1) to advertise the corresponding (AFI, SAFI) pair, as specified in [RFC4760]. New TLVs carried in the Link_State Attribute defined in [RFC7752] are also defined in order to carry the attributes of a TE Policy in the subsequent sections.

The format of "Link-State NLRI" is defined in [RFC7752] as follows:



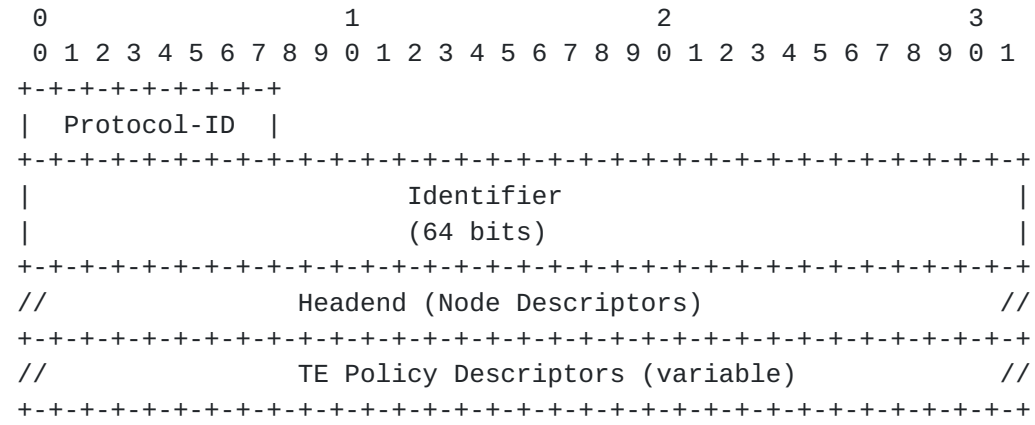
A new "NLRI Type" is defined for TE Policy Information as following:

o NLRI Type: TE Policy NLRI value 5.

The format of this new NLRI type is defined in Section 3 below.

3. TE Policy NLRI

This document defines the new TE Policy NLRI-Type and its format as shown in the following figure:



where:

- Protocol-ID field specifies the component that owns the TE Policy state in the advertising node. The following new Protocol-IDs are defined and apply to the TE Policy NLRI:

Protocol-ID	NLRI information source protocol
8	RSVP-TE
9	Segment Routing

- "Identifier" is an 8 octet value as defined in [RFC7752].

- "Headend" consists of a Local Node Descriptor (TLV 256) as defined in [RFC7752].

- "TE Policy Descriptors" consists of one or more of the TLVs listed as below:

Codepoint	Descriptor TLVs
550	Tunnel ID
551	LSP ID
552	IPv4/6 Tunnel Head-end address
553	IPv4/6 Tunnel Tail-end address
554	SR Policy Candidate Path
555	Local MPLS Cross Connect

The Local Node Descriptor TLV MUST include the following Node Descriptor TLVs:

- BGP Router-ID (TLV 516) [I-D.ietf-idr-bgpls-segment-routing-epe], which contains a valid BGP Identifier of the local node.

- Autonomous System Number (TLV 512) [RFC7752], which contains the ASN or AS Confederation Identifier (ASN) [RFC5065], if confederations are used, of the local node.

The Local Node Descriptor TLV SHOULD include the following Node Descriptor TLVs:

- IPv4 Router-ID of Local Node (TLV 1028) [RFC7752], which contains the IPv4 TE Router-ID of the local node when one is provisioned.

- IPv6 Router-ID of Local Node (TLV 1029) [RFC7752], which contains the IPv6 TE Router-ID of the local node when one is provisioned.

The Local Node Descriptor TLV MAY include the following Node Descriptor TLVs:

- Member-ASN (TLV 517) [I-D.ietf-idr-bgpls-segment-routing-epe], which contains the ASN of the confederation member (i.e. Member-AS Number), if BGP confederations are used, of the local node.

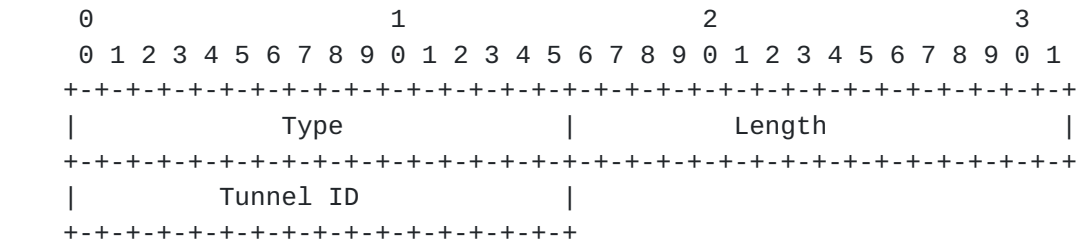
- Node Descriptors as defined in [RFC7752].

4. TE Policy Descriptors

This sections defines the TE Policy Descriptors TLVs which are used to describe the TE Policy being advertised by using the new BGP-LS TE Policy NLRI type defined in Section 3.

4.1. Tunnel Identifier (Tunnel ID)

The Tunnel Identifier TLV contains the Tunnel ID defined in [RFC3209] and is used for RSVP-TE protocol TE Policies. It has the following format:

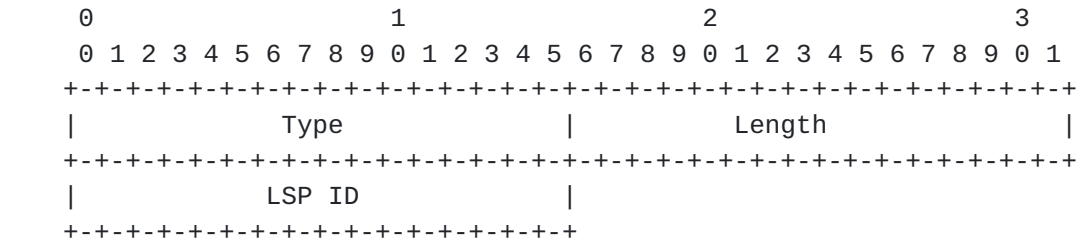


where:

- Type: 550
- Length: 2 octets.
- Tunnel ID: 2 octets as defined in [RFC3209].

4.2. LSP Identifier (LSP ID)

The LSP Identifier TLV contains the LSP ID defined in [RFC3209] and is used for RSVP-TE protocol TE Policies. It has the following format:

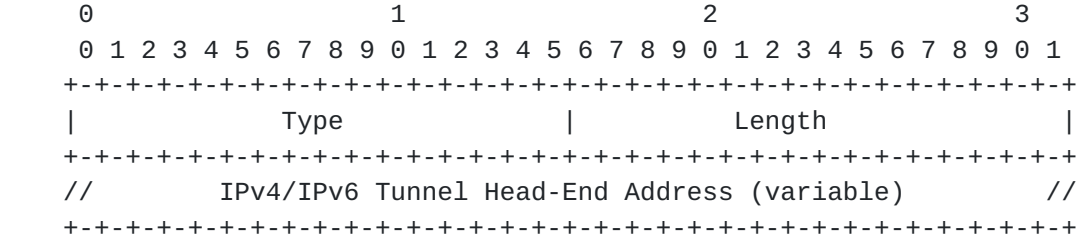


where:

- Type: 551
- Length: 2 octets.
- LSP ID: 2 octets as defined in [RFC3209].

4.3. IPv4/IPv6 Tunnel Head-End Address

The IPv4/IPv6 Tunnel Head-End Address TLV contains the Tunnel Head-End Address defined in [RFC3209] and is used for RSVP-TE protocol TE Policies. It has following format:



where:

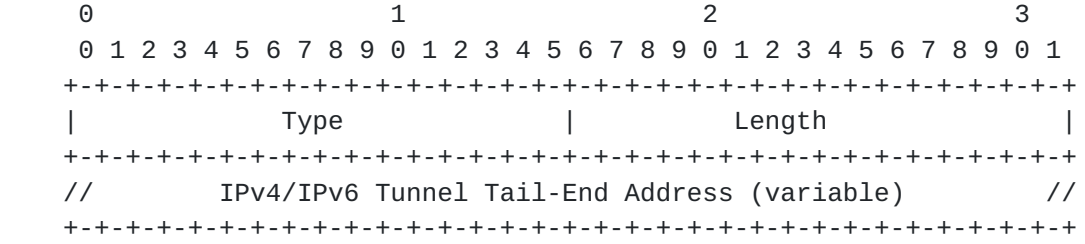
- Type: 552
- Length: 4 or 16 octets.

When the IPv4/IPv6 Tunnel Head-end Address TLV contains an IPv4 address, its length is 4 (octets).

When the IPv4/IPv6 Tunnel Head-end Address TLV contains an IPv6 address, its length is 16 (octets).

4.4. IPv4/IPv6 Tunnel Tail-End Address

The IPv4/IPv6 Tunnel Tail-End Address TLV contains the Tunnel Tail-End Address defined in [RFC3209] and is used for RSVP-TE protocol TE Policies. It has following format:



where:

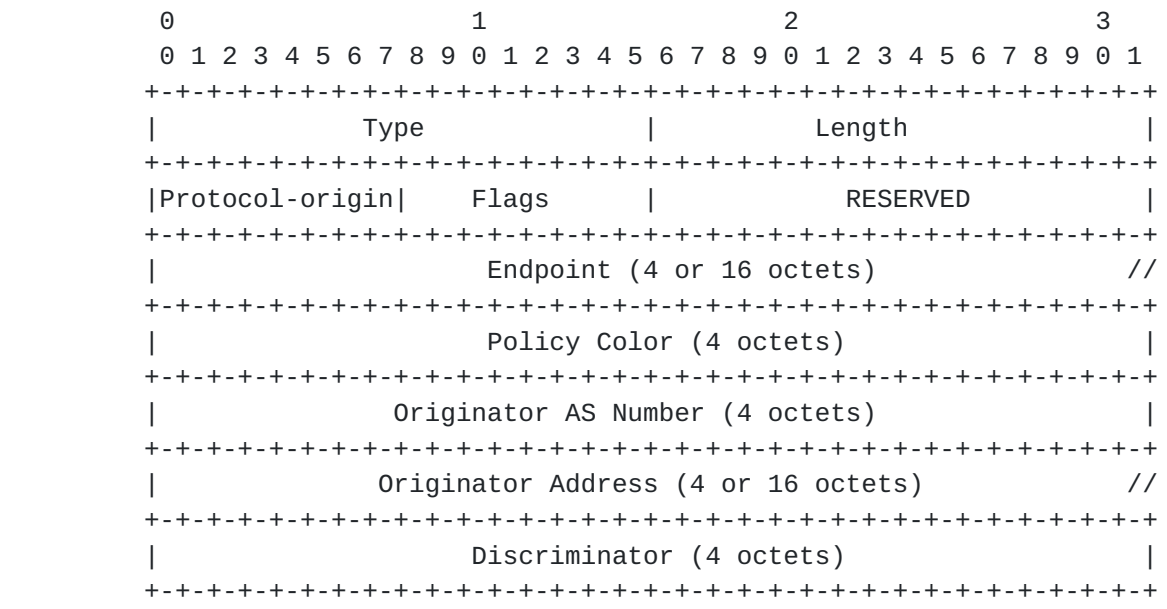
- Type: 553
- Length: 4 or 16 octets.

When the IPv4/IPv6 Tunnel Tail-end Address TLV contains an IPv4 address, its length is 4 (octets).

When the IPv4/IPv6 Tunnel Tail-end Address TLV contains an IPv6 address, its length is 16 (octets).

4.5. SR Policy Candidate Path Descriptor

The SR Policy Candidate Path Descriptor TLV identifies a Segment Routing Policy candidate path (CP) as defined in [I-D.ietf-spring-segment-routing-policy] and has the following format:



where:

- Type: 554
- Length: variable (valid values are 24, 36 or 48 octets)
- Protocol-Origin : 1 octet field which identifies the protocol or component which is responsible for the instantiation of this path. Following protocol-origin codepoints are defined in this document.

Code Point	Protocol Origin
1	PCEP
2	BGP SR Policy
3	Local (via CLI, Yang model through NETCONF, gRPC, etc.)

- Flags: 1 octet field with following bit positions defined. Other bits SHOULD be cleared by originator and MUST be ignored by receiver.

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|E|O|           |
+-+-+-+-+-+-+-+-+
```

where:

  - E-Flag : Indicates the encoding of endpoint as IPv6 address when set and IPv4 address when clear

  - O-Flag : Indicates the encoding of originator address as IPv6 address when set and IPv4 address when clear

- Reserved : 2 octets which SHOULD be set to 0 by originator and MUST be ignored by receiver.

- Endpoint : 4 or 16 octets (as indicated by the flags) containing the address of the endpoint of the SR Policy

- Color : 4 octets that indicates the color of the SR Policy

- Originator ASN : 4 octets to carry the 4 byte encoding of the ASN of the originator. Refer [I-D.ietf-spring-segment-routing-policy] Sec 2.4 for details.

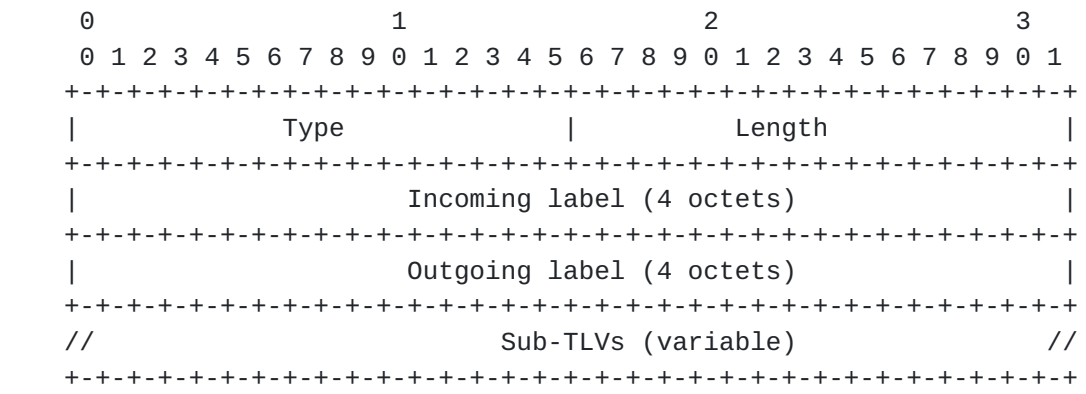
- Originator Address : 4 or 16 octets (as indicated by the flags) to carry the address of the originator. Refer [I-D.ietf-spring-segment-routing-policy] Sec 2.4 for details.

- Discriminator : 4 octets to carry the discrimator of the path. Refer [I-D.ietf-spring-segment-routing-policy] Sec 2.5 for details.

4.6. Local MPLS Cross Connect

The Local MPLS Cross Connect TLV identifies a local MPLS state in the form of incoming label and interface followed by an outgoing label and interface. Outgoing interface may appear multiple times (for multicast states). It is used with Protocol ID set to "Static Configuration" value 5 as defined in [RFC7752].

The Local MPLS Cross Connect TLV has the following format:



where:

- Type: 555
- Length: variable.
- Incoming and Outgoing labels: 4 octets each.
- Sub-TLVs: following Sub-TLVs are defined:
  - Interface Sub-TLV
  - Forwarding Equivalent Class (FEC)

The Local MPLS Cross Connect TLV:

MUST have an incoming label.

MUST have an outgoing label.

MAY contain an Interface Sub-TLV having the I-flag set.

MUST contain at least one Interface Sub-TLV having the I-flag unset.

MAY contain multiple Interface Sub-TLV having the I-flag unset. This is the case of a multicast MPLS cross connect.

MAY contain a FEC Sub-TLV.

The following sub-TLVs are defined for the Local MPLS Cross Connect TLV:

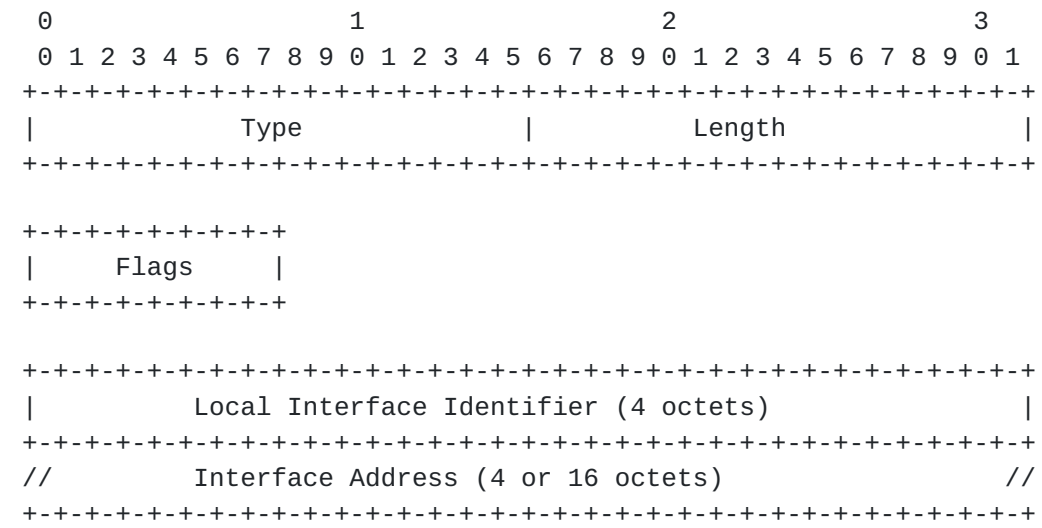
Codepoint	Descriptor TLV
556	MPLS Cross Connect Interface
557	MPLS Cross Connect FEC

These are defined in the following sub-sections.

4.6.1. MPLS Cross Connect Interface

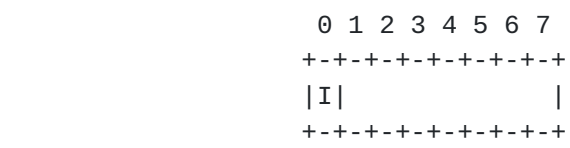
The MPLS Cross Connect Interface sub-TLV is optional and contains the identifier of the interface (incoming or outgoing) in the form of an IPv4 address or an IPv6 address.

The MPLS Cross Connect Interface sub-TLV has the following format:



where:

- Type: 556
- Length: 9 or 21.
- Flags: 1 octet of flags defined as follows:



where:

  * I-Flag is the Interface flag. When set, the Interface Sub-TLV describes an incoming interface. If the I-flag is not set, then the Interface Sub-TLV describes an outgoing interface.

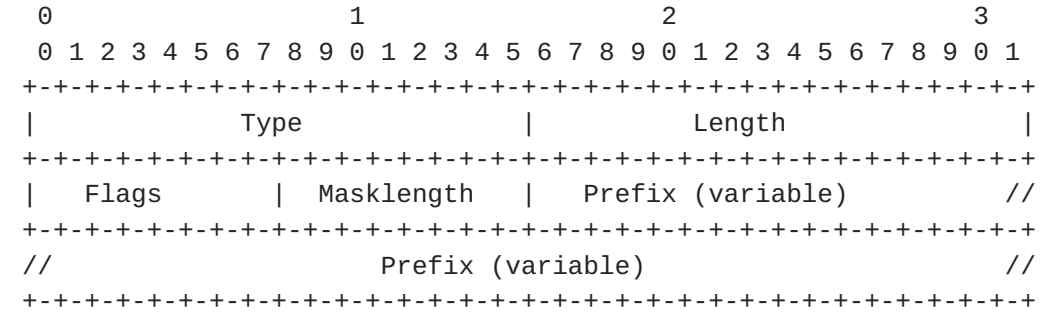
- Local Interface Identifier: a 4 octet identifier.

- Interface address: a 4 octet IPv4 address or a 16 octet IPv6 address.

4.6.2. MPLS Cross Connect FEC

The MPLS Cross Connect FEC sub-TLV is optional and contains the FEC associated to the incoming label.

The MPLS Cross Connect FEC sub-TLV has the following format:

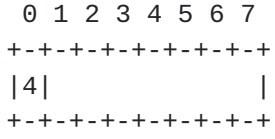


where:

- Type: 557

- Length: variable.

- Flags: 1 octet of flags defined as follows:



where:

  * 4-Flag is the IPv4 flag. When set, the FEC Sub-TLV describes an IPv4 FEC. If the 4-flag is not set, then the FEC Sub-TLV describes an IPv6 FEC.

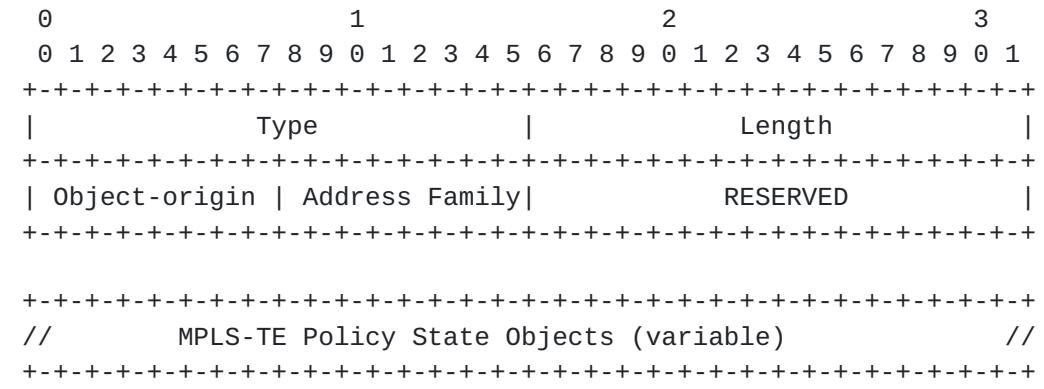
- Mask Length: 1 octet of prefix length.

o Prefix: an IPv4 or IPv6 prefix whose mask length is given by the " Mask Length" field padded to an octet boundary.

5. MPLS-TE Policy State TLV

A new TLV called "MPLS-TE Policy State TLV", is used to describe the characteristics of the MPLS-TE Policy and it is carried in the optional non-transitive BGP Attribute "LINK_STATE Attribute" defined in [RFC7752]. These MPLS-TE Policy characteristics include the characteristics and attributes of the policy, its dataplane, explicit path, Quality of Service (QoS) parameters, route information, the protection mechanisms, etc.

The MPLS-TE Policy State TLV has the following format:



where:

MPLS-TE Policy State TLV

o Type: 1200

o Length: the total length of the MPLS-TE Policy State TLV not including Type and Length fields.

o Object-origin: identifies the component (or protocol) from which the contained object originated. This allows for objects defined in different components to be collected while avoiding the possible codepoint collisions among these components. Following object-origin codepoints are defined in this document.

Code Point	Object Origin
1	RSVP-TE
2	PCEP
3	Local/Static

- Address Family: describes the address family used to setup the MPLS-TE policy. The following address family values are defined in this document:

Code Point	Dataplane
1	MPLS-IPv4
2	MPLS-IPv6

- RESERVED: 16-bit field. SHOULD be set to 0 on transmission and MUST be ignored on receipt.

- TE Policy State Objects: Rather than replicating all these objects in this document, the semantics and encodings of the objects as defined in RSVP-TE and PCEP are reused.

The state information is carried in the "MPLS-TE Policy State Objects" with the following format as described in the sub-sections below.

5.1. RSVP Objects

RSVP-TE objects are encoded in the "MPLS-TE Policy State Objects" field of the MPLS-TE Policy State TLV and consists of MPLS TE LSP objects defined in RSVP-TE [RFC3209] [RFC3473]. Rather than replicating all MPLS TE LSP related objects in this document, the semantics and encodings of the MPLS TE LSP objects are re-used. These MPLS TE LSP objects are carried in the MPLS-TE Policy State TLV.

When carrying RSVP-TE objects, the "Object-Origin" field is set to "RSVP-TE".

The following RSVP-TE Objects are defined:

- SENDER_TSPEC and FLOW_SPEC [RFC2205]

- SESSION_ATTRIBUTE [RFC3209]
- EXPLICIT_ROUTE Object (ERO) [RFC3209]
- ROUTE_RECORD Object (RRO) [RFC3209]
- FAST_REROUTE Object [RFC4090]
- DETOUR Object [RFC4090]
- EXCLUDE_ROUTE Object (XRO) [RFC4874]
- SECONDARY_EXPLICIT_ROUTE Object (SERO) [RFC4873]
- SECONDARY_RECORD_ROUTE (SRRO) [RFC4873]
- LSP_ATTRIBUTES Object [RFC5420]
- LSP_REQUIRED_ATTRIBUTES Object [RFC5420]
- PROTECTION Object [RFC3473][RFC4872][RFC4873]
- ASSOCIATION Object [RFC4872]
- PRIMARY_PATH_ROUTE Object [RFC4872]
- ADMIN_STATUS Object [RFC3473]
- LABEL_REQUEST Object [RFC3209][RFC3473]

For the MPLS TE LSP Objects listed above, the corresponding sub-objects are also applicable to this mechanism. Note that this list is not exhaustive, other MPLS TE LSP objects which reflect specific characteristics of the MPLS TE LSP can also be carried in the LSP state TLV.

5.2. PCEP Objects

PCEP objects are encoded in the "MPLS-TE Policy State Objects" field of the MPLS-TE Policy State TLV and consists of PCEP objects defined in [RFC5440]. Rather than replicating all MPLS TE LSP related objects in this document, the semantics and encodings of the MPLS TE LSP objects are re-used. These MPLS TE LSP objects are carried in the MPLS-TE Policy State TLV.

When carrying PCEP objects, the "Object-Origin" field is set to "PCEP".

The following PCEP Objects are defined:

- METRIC Object [RFC5440]

- BANDWIDTH Object [RFC5440]

For the MPLS TE LSP Objects listed above, the corresponding sub-objects are also applicable to this mechanism. Note that this list is not exhaustive, other MPLS TE LSP objects which reflect specific characteristics of the MPLS TE LSP can also be carried in the TE Policy State TLV.

6. SR Policy State TLVs

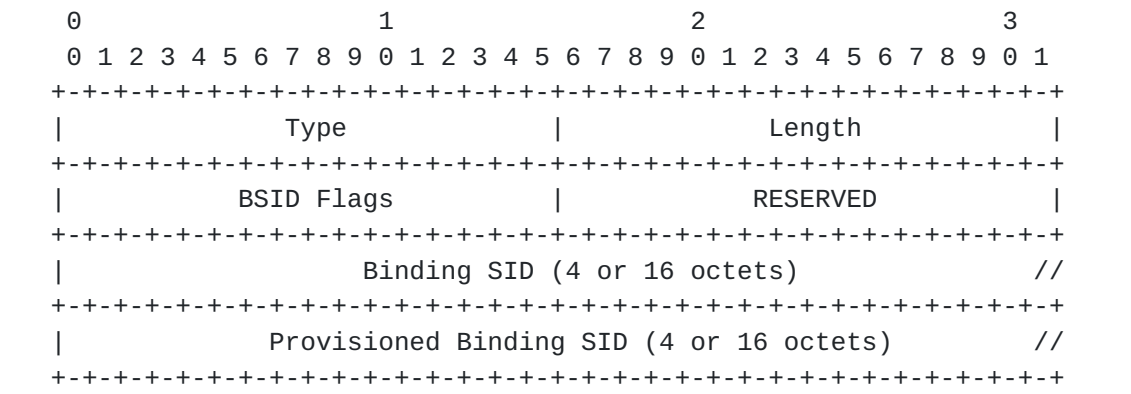
Segment Routing Policy (SR Policy) architecture is specified in [I-D.ietf-spring-segment-routing-policy]. A SR Policy can comprise of one or more candidate paths (CP) of which at a given time one and only one may be active (i.e. installed in forwarding and usable for steering of traffic). Each CP in turn may have one or more SID-List of which one or more may be active; when multiple are active then traffic is load balanced over them.

This section defines the various TLVs which enable the headend to report the state of an SR Policy, its CP(s), SID-List(s) and their status. These TLVs are carried in the optional non-transitive BGP Attribute "LINK_STATE Attribute" defined in [RFC7752] and enable the same consistent form of reporting for SR Policy state irrespective of the Protocol-Origin used to provision the policy. Detailed procedure is described in Section 7 .

6.1. SR Binding SID

The SR Binding SID (BSID) is an optional TLV that provides the BSID and its attributes for the SR Policy CP. The TLV MAY also optionally contain the Provisioned BSID value for reporting when explicitly provisioned.

The TLV has the following format:

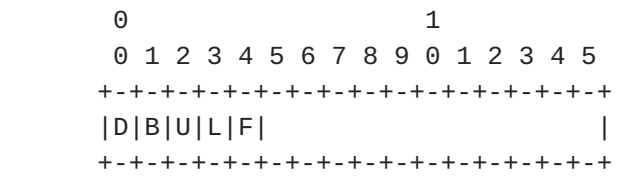


where:

o Type: 1201

o Length: variable (valid values are 12 or 36 octets)

o BSID Flags: 2 octet field that indicates attribute and status of the Binding SID (BSID) associated with this CP. The following bit positions are defined and the semantics are described in detail in [I-D.ietf-spring-segment-routing-policy]. Other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

   * D-Flag : Indicates the dataplane for the BSIDs and if they are 16 octet SRv6 SID when set and are 4 octet SR/MPLS label value when clear.

   * B-Flag : Indicates the allocation of the value in the BSID field when set and indicates that BSID is not allocated when clear.

   * U-Flag : Indicates the provisioned BSID value is unavailable when set.

   * L-Flag : Indicates the BSID value is from the Segment Routing Local Block (SRLB) of the headend node when set and is from the local dynamic label pool when clear

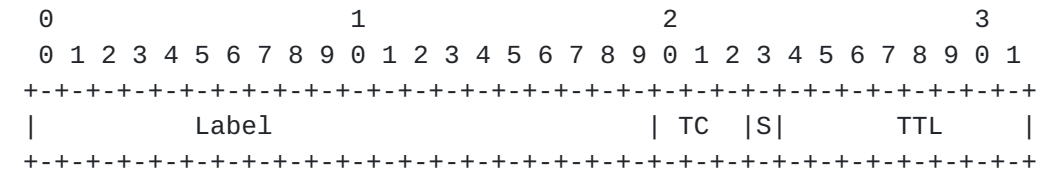
  * F-Flag : Indicates the BSID value is one allocated from dynamic label pool due to fallback (e.g. when specified BSID is unavailable) when set.

- RESERVED: 2 octets. SHOULD be set to 0 by originator and MUST be ignored by receiver.

- Binding SID: It indicates the operational or allocated BSID value for the CP based on the status flags.

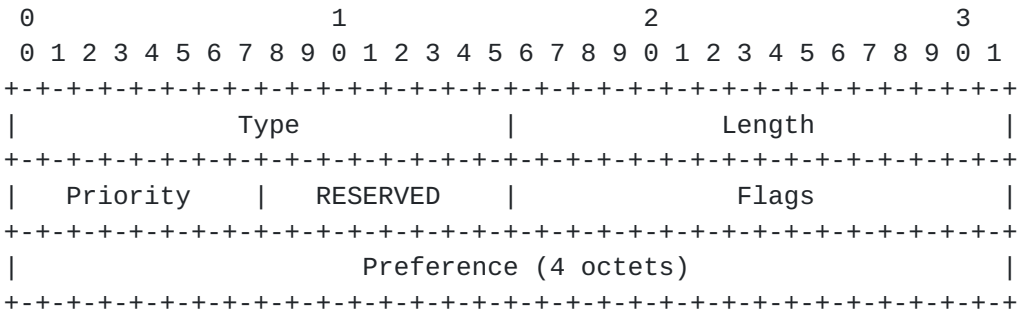
- Provisioned BSID: It is used to report the explicitly provisioned BSID value regardless of whether it is successfully allocated or not. The field is set to value 0 when BSID has not been specified or provisioned for the CP.

The BSID fields above are 4 octet carrying the MPLS Label or 16 octets carrying the SRv6 SID based on the BSID D-flag. When carrying the MPLS Label, as shown in the figure below, the TC, S and TTL (total of 12 bits) are RESERVED and SHOULD be set to 0 by originator and MUST be ignored by the receiver.



6.2. SR Candidate Path State

The SR Candidate Path (CP) State TLV provides the operational status and attributes of the SR Policy at the CP level. The TLV has the following format:



where:

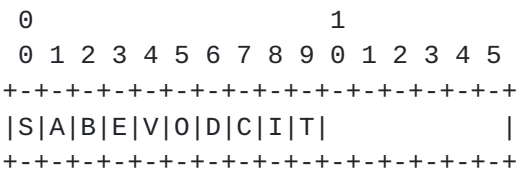
- Type: 1202

- Length: 8 octets

- Priority : 1 octet value which indicates the priority of the CP. Refer Section 2.12 of [I-D.ietf-spring-segment-routing-policy].

- RESERVED: 1 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.

- Flags: 2 octet field that indicates attribute and status of the CP. The following bit positions are defined and the semantics are described in detail in [I-D.ietf-spring-segment-routing-policy]. Other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

  * S-Flag : Indicates the CP is in administrative shut state when set

  * A-Flag : Indicates the CP is the active path (i.e. one provisioned in the forwarding plane) for the SR Policy when set

  * B-Flag : Indicates the CP is the backup path (i.e. one identified for path protection of the active path) for the SR Policy when set

  * E-Flag : Indicates that the CP has been evaluated for validity (e.g. headend may evaluate CPs based on their preferences) when set

  * V-Flag : Indicates the CP has at least one valid SID-List when set. When the E-Flag is clear (i.e. the CP has not been evaluated), then this flag MUST be set to 0 by the originator and ignored by the receiver.

  * O-Flag : Indicates the CP was instantiated by the headend due to an on-demand-nexthop trigger based on local template when set. Refer Section 8.5 of [I-D.ietf-spring-segment-routing-policy].

  * D-Flag : Indicates the CP was delegated for computation to a PCE/controller when set

  * C-Flag : Indicates the CP was provisioned by a PCE/controller when set

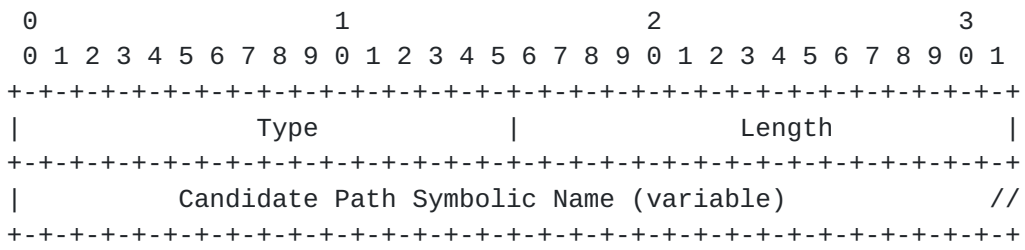
  * I-Flag : Indicates the CP will perform the "drop upon invalid" behavior when no other active path is available for this SR Policy and this path is the one with best preference amongst the available CPs. Refer Section 8.2 of [I-D.ietf-spring-segment-routing-policy].

  * T-Flag : Indicates the CP has been marked as eligible for use as Transit Policy on the headend when set. Refer Section 8.3 of [I-D.ietf-spring-segment-routing-policy].

- Preference : 4 octet value which indicates the preference of the CP. Refer Section 2.7 of [I-D.ietf-spring-segment-routing-policy].

6.3. SR Candidate Path Name

The SR Candidate Path Name TLV is an optional TLV that is used to carry the symbolic name associated with the candidate path. The TLV has the following format:



where:

- Type: 1203

- Length: variable

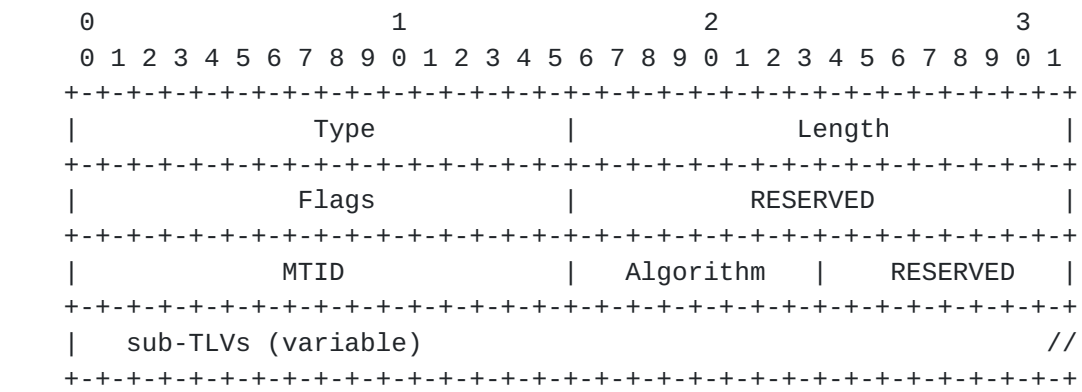
- CP Name : Symbolic name for the CP. It is a string of printable ASCII characters without a NULL terminator.

6.4. SR Candidate Path Constraints

The SR Candidate Path Constraints TLV is an optional TLV that is used to report the constraints associated with the candidate path. The constraints are generally applied to a dynamic candidate path which is computed by the headend. The constraints may also be applied to an explicit path where the headend is expected to validate that the path expresses satisfies the specified constraints and the path is to

be invalidated by the headend when the constraints are no longer met (e.g. due to topology changes).

The TLV has the following format:

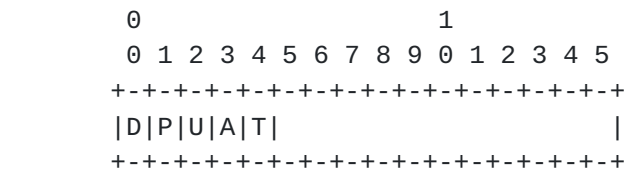


where:

o Type: 1204

o Length: variable

o Flags: 2 octet field that indicates the constraints that are being applied to the CP. The following bit positions are defined and the other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

   * D-Flag : Indicates that the CP needs to use SRv6 dataplane when set and SR/MPLS dataplane when clear

   * P-Flag : Indicates that the CP needs to use only protected SIDs when set

   * U-Flag : Indicates that the CP needs to use only unprotected SIDs when set

   * A-Flag : Indicates that the CP needs to use the SIDs belonging to the specified SR Algorithm only when set

  * T-Flag: Indicates that the CP needs to use the SIDs belonging to the specified topology only when set

- RESERVED: 2 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.

- MTID : Indicates the multi-topology identifier of the IGP topology that is preferred to be used when the path is setup. When the T-flag is set then the path is strictly useing the specified topology SIDs only.

- Algorithm : Indicates the algorithm that is preferred to be used when the path is setup. When the A-flag is set then the path is strictly using the specified algorithm SIDs only.

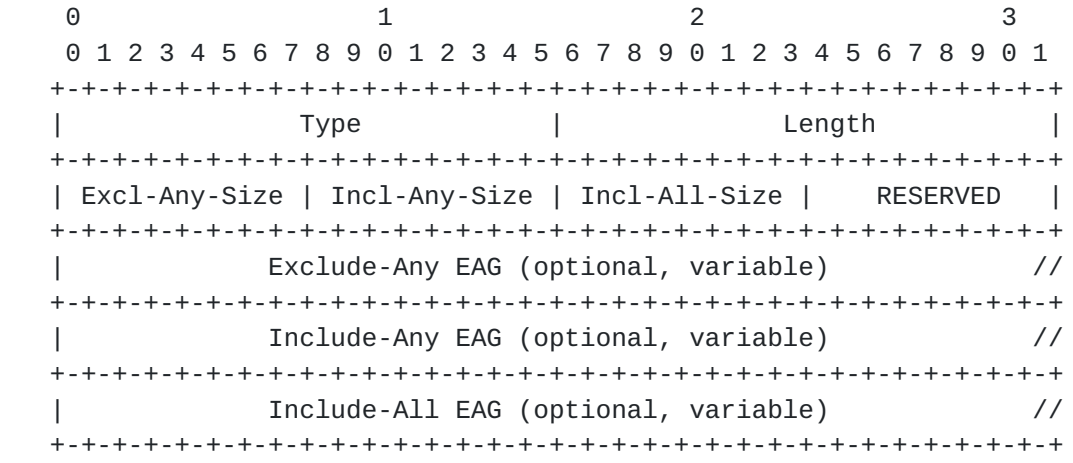
- RESERVED: 1 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.

- sub-TLVs: optional sub-TLVs MAY be included in this TLV to describe other constraints.

The following constraint sub-TLVs are defined for the SR CP Constraints TLV.

6.4.1. SR Affinity Constraint

The SR Affinity Constraint sub-TLV is an optional sub-TLV that is used to carry the affinity constraints [RFC2702] associated with the candidate path. The affinity is expressed in terms of Extended Admin Group (EAG) as defined in [RFC7308]. The TLV has the following format:

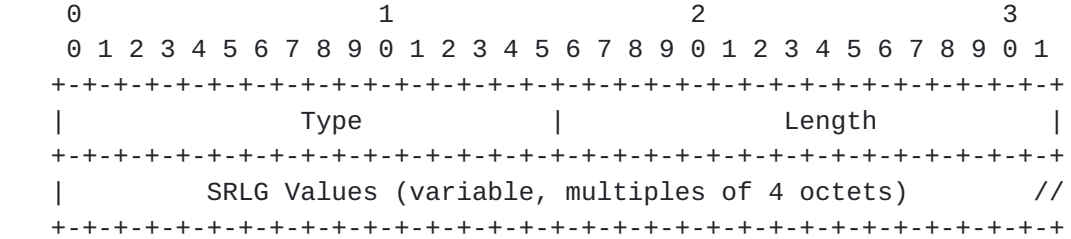


where:

- Type: 1208
- Length: variable, dependent on the size of the Extended Admin Group. MUST be a multiple of 4 octets.
- Exclude-Any-Size : one octet to indicate the size of Exclude-Any EAG bitmask size in multiples of 4 octets. (e.g. value 0 indicates the Exclude-Any EAG field is skipped, value 1 indicates that 4 octets of Exclude-Any EAG is included)
- Include-Any-Size : one octet to indicate the size of Include-Any EAG bitmask size in multiples of 4 octets. (e.g. value 0 indicates the Include-Any EAG field is skipped, value 1 indicates that 4 octets of Include-Any EAG is included)
- Include-All-Size : one octet to indicate the size of Include-All EAG bitmask size in multiples of 4 octets. (e.g. value 0 indicates the Include-All EAG field is skipped, value 1 indicates that 4 octets of Include-All EAG is included)
- RESERVED: 1 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.
- Exclude-Any EAG : the bitmask used to represent the affinities to be excluded from the path.
- Include-Any EAG : the bitmask used to represent the affinities to be included in the path.
- Include-All EAG : the bitmask used to represent the all affinities to be included in the path.

6.4.2. SR SRLG Constraint

The SR SRLG Constraint sub-TLV is an optional sub-TLV that is used to carry the Shared Risk Link Group (SRLG) values [RFC4202] that are to be excluded from the candidate path. The TLV has the following format:

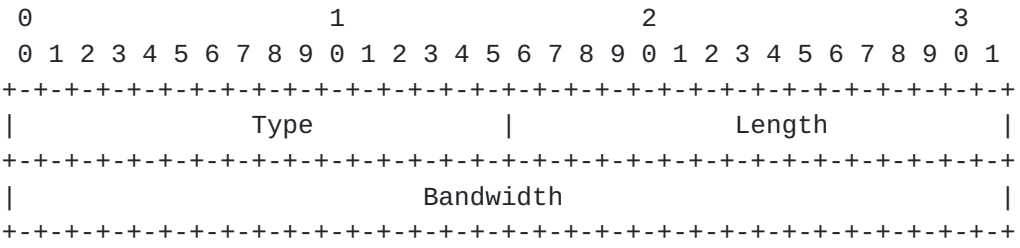


where:

- Type: 1209
- Length: variable, dependent on the number of SRLGs encoded. MUST be a multiple of 4 octets.
- SRLG Values : One or more SRLG values (each of 4 octets).

6.4.3. SR Bandwidth Constraint

The SR Bandwidth Constraint sub-TLV is an optional sub-TLV that is used to indicate the desired bandwidth availability that needs to be ensured for the candidate path. The TLV has the following format:



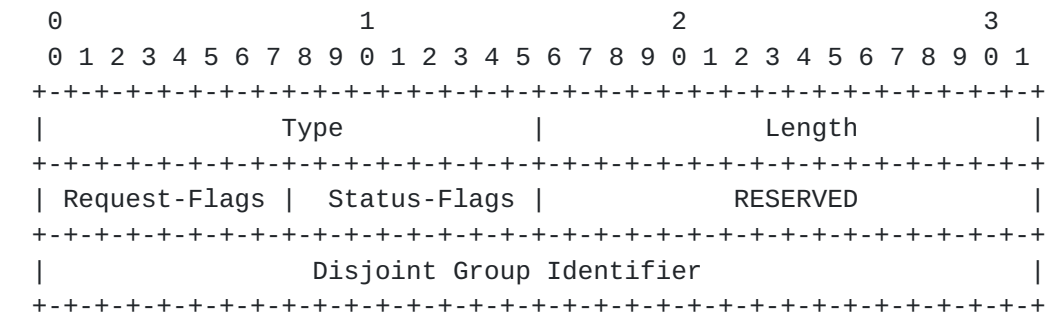
where:

- Type: 1210
- Length: 4 octects
- Bandwidth : 4 octets which specify the desired bandwidth in unit of bytes per second in IEEE floating point format.

6.4.4. SR Disjoint Group Constraint

The SR Disjoint Group Constraint sub-TLV is an optional sub-TLV that is used to carry the disjointness constraint associated with the candidate path. The disjointness between two SR Policy Candidate Paths is expressed by associating them with the same disjoint group identifier and then specifying the type of disjointness required between their paths. The computation is expected to achieve the highest level of disjointness requested and when that is not possible then fallback to a lesser level progressively based on the levels indicated.

The TLV has the following format:

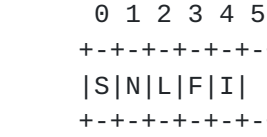


where:

o Type: 1211

o Length: 8 octets

o Request Flags : one octet to indicate the level of disjointness requested as specified in the form of flags. The following flags are defined and the other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

   * S-Flag : Indicates that SRLG disjointness is requested

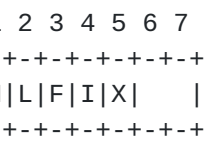
   * N-Flag : Indicates that node disjointness is requested when

   * L-Flag : Indicates that link disjointness is requested when

   * F-Flag : Indicates that the computation may fallback to a lower level of disjointness amongst the ones requested when all cannot be achieved

   * I-Flag : Indicates that the computation may fallback to the default best path (e.g. IGP path) in case of none of the desired disjointness can be achieved.

o Status Flags : one octet to indicate the level of disjointness that has been achieved by the computation as specified in the form of flags. The following flags are defined and the other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

* S-Flag : Indicates that SRLG disjointness is achieved

* N-Flag : Indicates that node disjointness is achieved

* L-Flag : Indicates that link disjointness is achieved

* F-Flag : Indicates that the computation has fallen back to a lower level of disjointness that requested.

* I-Flag : Indicates that the computation has fallen back to the best path (e.g. IGP path) and disjointness has not been achieved

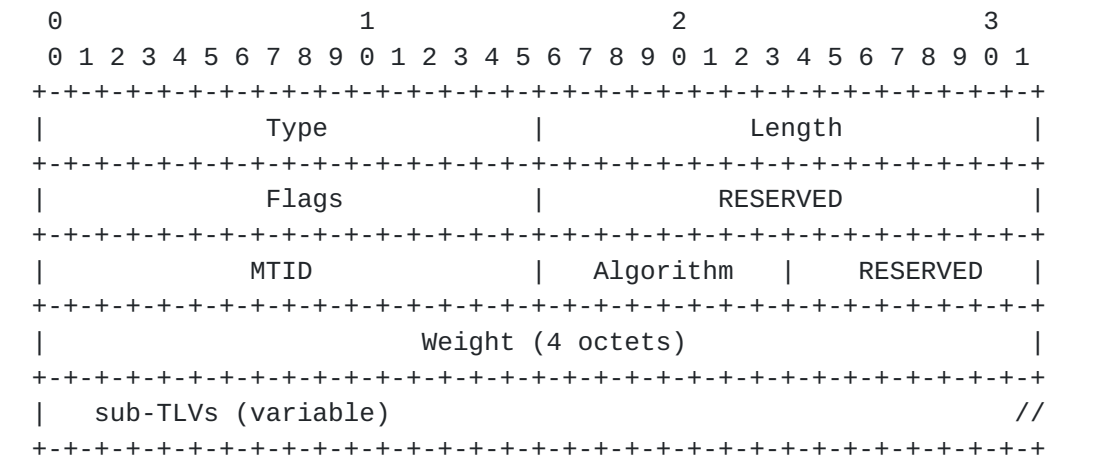
* X-Flag : Indicates that the disjointness constraint could not be achieved and hence path has been invalidated

o RESERVED: 2 octets. SHOULD be set to 0 by originator and MUST be ignored by receiver.

o Disjointness Group Identifier : 4 octet value that is the group identifier for a set of disjoint paths

6.5. SR Segment List

The SR Segment List TLV is used to report the SID-List(s) of a candidate path. The TLV has following format:

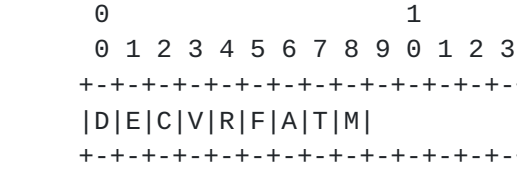


where:

o Type: 1205

o Length: variable

o Flags: 2 octet field that indicates attribute and status of the SID-List.The following bit positions are defined and the semantics are described in detail in [I-D.ietf-spring-segment-routing-policy]. Other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

   * D-Flag : Indicates the SID-List is comprised of SRv6 SIDs when set and indicates it is comprised of SR/MPLS labels when clear.

   * E-Flag : Indicates that SID-List is an explicit path when set and indicates dynamic path when clear.

   * C-Flag : Indicates that SID-List has been computed for a dynamic path when set. It is always reported as set for explicit paths.

   * V-Flag : Indicates the SID-List has passed verification or its verification was not required when set and failed verification when clear.

  * R-Flag : Indicates that the first Segment has been resolved when set and failed resolution when clear.

  * F-Flag : Indicates that the computation for the dynamic path failed when set and succeeded (or not required in case of explicit path) when clear

  * A-Flag : Indicates that all the SIDs in the SID-List belong to the specified algorithm when set.

  * T-Flag : Indicates that all the SIDs in the SID-List belong to the specified topology (identified by the multi-topology ID) when set.

  * M-Flag : Indicates that the SID-list has been removed from the forwarding plane due to fault detection by a monitoring mechanism (e.g. BFD) when set and indicates no fault detected or monitoring is not being done when clear.

- RESERVED: 2 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.

- MTID : 2 octet that indicates the multi-topology identifier of the IGP topology to be used when the T-flag is set.

- Algorithm: 1 octet that indicates the algorithm of the SIDs used in the SID-List when the A-flag is set.

- RESERVED: 1 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.

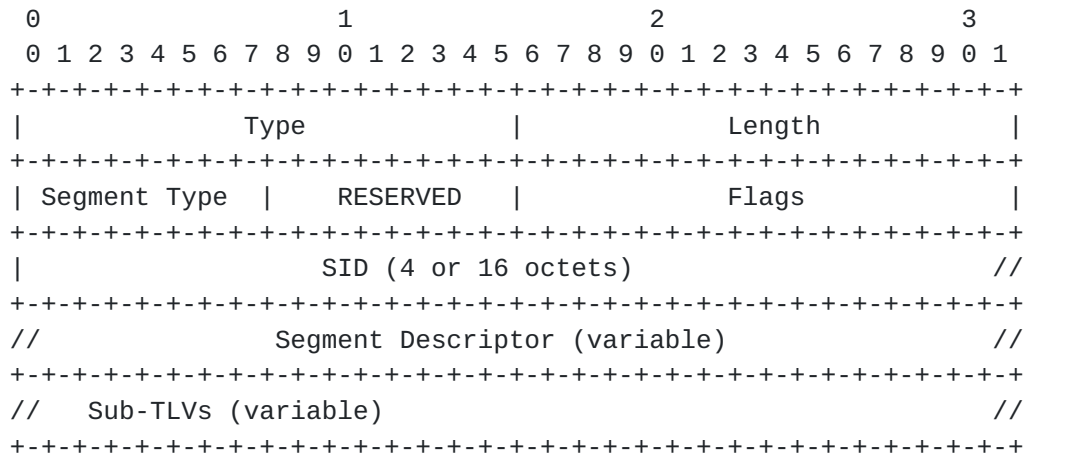
- Weight: 4 octet field that indicates the weight associated with the SID-List for weighted load-balancing. Refer Section 2.2 and 2.11 of [I-D.ietf-spring-segment-routing-policy].

- Sub-TLVs : variable and contains the ordered set of Segments and any other optional attributes associated with the specific SID-List.

The SR Segment sub-TLV (defined in Section 6.6) MUST be included as an ordered set of sub-TLVs within the SR Segment List TLV when the SID-List is not empty. A SID-List may be empty in certain cases (e.g. for a dynamic path) where the headend has not yet performed the computation and hence not derived the segments required for the path; in such cases, the SR Segment List TLV SHOULD NOT include any SR Segment sub-TLVs.

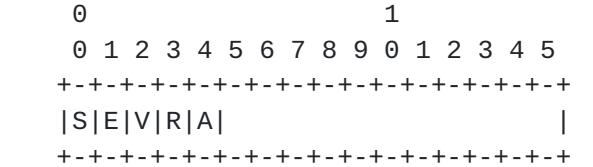
6.6. SR Segment

The SR Segment sub-TLV describes a single segment in a SID-List. One or more instances of this sub-TLV in an ordered manner constitute a SID-List for a SR Policy candidate path. It is a sub-TLV of the SR Segment List TLV and has following format:



where:

- Type: 1206
- Length: variable
- Segment Type : 1 octet which indicates the type of segment (refer Section 6.6.1 for details)
- RESERVED: 1 octet. SHOULD be set to 0 by originator and MUST be ignored by receiver.
- Flags: 2 octet field that indicates attribute and status of the Segment and its SID. The following bit positions are defined and the semantics are described in detail in [I-D.ietf-spring-segment-routing-policy]. Other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

  * S-Flag : Indicates the presence of SID value in the SID field when set and that no value is indicated when clear.

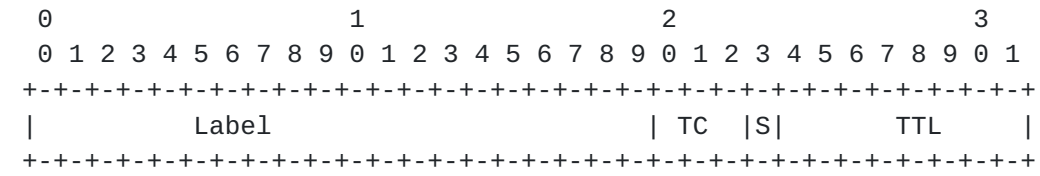
  * E-Flag : Indicates the SID value is explicitly provisioned value (locally on headend or via controller/PCE) when set and is a dynamically resolved value by headend when clear

  * V-Flag : Indicates the SID has passed verification or did not require verification when set and failed verification when clear.

  * R-Flag : Indicates the SID has been resolved or did not require resolution (e.g. because it is not the first SID) when set and failed resolution when clear.

  * A-Flag : Indicates that the Algorithm indicated in the Segment descriptor is valid when set. When clear, it indicates that the headend is unable to determine the algorithm of the SID.

- SID : 4 octet carrying the MPLS Label or 16 octets carrying the SRv6 SID based on the Segment Type. When carrying the MPLS Label, as shown in the figure below, the TC, S and TTL (total of 12 bits) are RESERVED and SHOULD be set to 0 by originator and MUST be ignored by the receiver.



- Segment Descriptor : variable size Segment descriptor based on the type of segment (refer Section 6.6.1 for details)

- Sub-Sub-TLVs : variable and contains any other optional attributes associated with the specific SID-List.

Currently no Sub-Sub-TLV of the SR Segment sub-TLV is defined.

6.6.1. Segment Descriptors

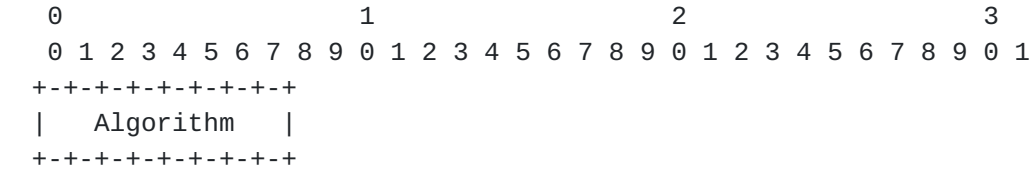
[I-D.ietf-spring-segment-routing-policy] section 4 defines multiple types of segments and their description. This section defines the encoding of the Segment Descriptors for each of those Segment types to be used in the Segment sub-TLV describes previously in Section 6.6.

The following types are currently defined:

Type	Segment Description
0	Invalid
1	SR-MPLS Label
2	SRv6 SID as IPv6 address
3	SR-MPLS Prefix SID as IPv4 Node Address
4	SR-MPLS Prefix SID as IPv6 Node Global Address
5	SR-MPLS Adjacency SID as IPv4 Node Address & Local Interface ID
6	SR-MPLS Adjacency SID as IPv4 Local & Remote Interface Addresses
7	SR-MPLS Adjacency SID as pair of IPv6 Global Address & Interface ID for Local & Remote nodes
8	SR-MPLS Adjacency SID as pair of IPv6 Global Addresses for the Local & Remote Interface
9	SRv6 END SID as IPv6 Node Global Address
10	SRv6 END.X SID as pair of IPv6 Global Address & Interface ID for Local & Remote nodes
11	SRv6 END.X SID as pair of IPv6 Global Addresses for the Local & Remote Interface

6.6.1.1. Type 1: SR-MPLS Label

The Segment is SR-MPLS type and is specified simply as the label. The format of its Segment Descriptor is as follows:



Where:

- Algorithm: 1 octet value that indicates the algorithm used for picking the SID. This is valid only when the A-flag has been set in the Segment TLV.

6.6.1.2. Type 2: SRv6 SID

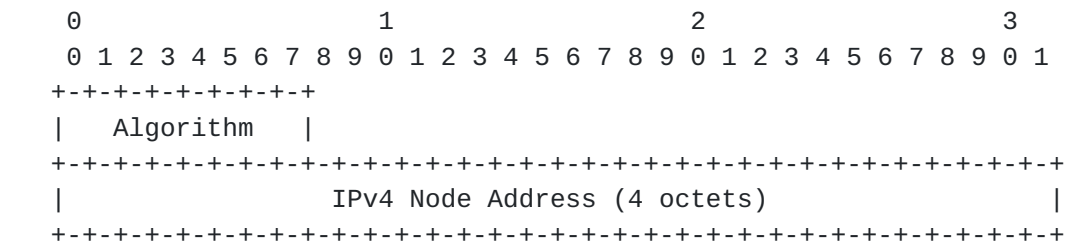
The Segment is SRv6 type and is specified simply as the SRv6 SID address. The format of its Segment Descriptor is as follows:

Where:

- Algorithm: 1 octet value that indicates the algorithm used for picking the SID. This is valid only when the A-flag has been set in the Segment TLV.

6.6.1.3. Type 3: SR-MPLS Prefix SID for IPv4

The Segment is SR-MPLS Prefix SID type and is specified as an IPv4 node address. The format of its Segment Descriptor is as follows:



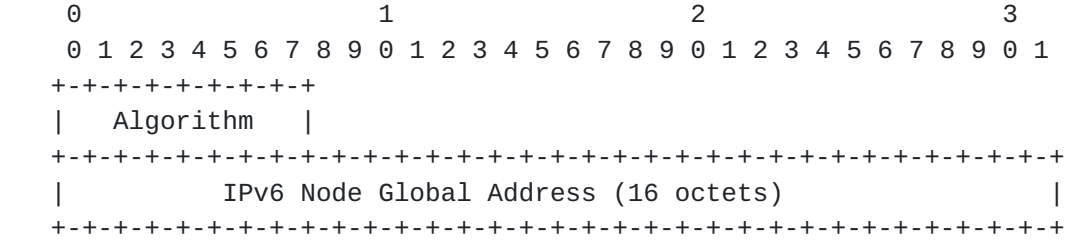
Where:

- Algorithm: 1 octet value that indicates the algorithm used for picking the SID

- IPv4 Node Address: 4 octet value which carries the IPv4 address associated with the node

6.6.1.4. Type 4: SR-MPLS Prefix SID for IPv6

The Segment is SR-MPLS Prefix SID type and is specified as an IPv6 global address. The format of its Segment Descriptor is as follows:



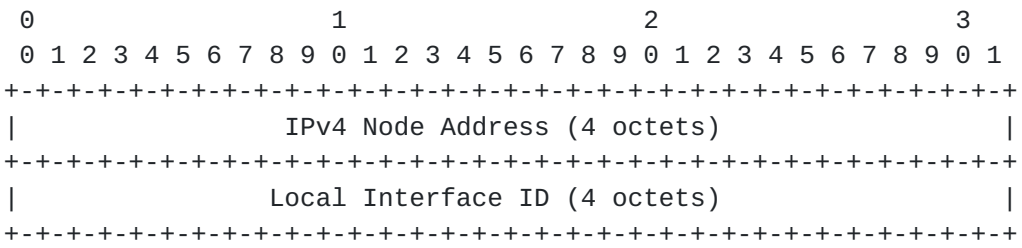
Where:

- Algorithm: 1 octet value that indicates the algorithm used for picking the SID

- IPv6 Node Global Address: 16 octet value which carries the IPv6 global address associated with the node

6.6.1.5. Type 5: SR-MPLS Adjacency SID for IPv4 with Interface ID

The Segment is SR-MPLS Adjacency SID type and is specified as an IPv4 node address along with the local interface ID on that node. The format of its Segment Descriptor is as follows:



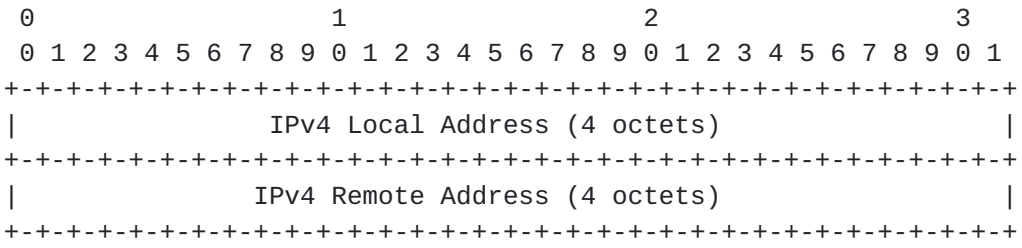
Where:

- IPv4 Node Address: 4 octet value which carries the IPv4 address associated with the node

- Local Interface ID : 4 octet value which carries the local interface ID of the node identified by the Node Address

6.6.1.6. Type 6: SR-MPLS Adjacency SID for IPv4 with Interface Address

The Segment is SR-MPLS Adjacency SID type and is specified as a pair of IPv4 local and remote addresses. The format of its Segment Descriptor is as follows:



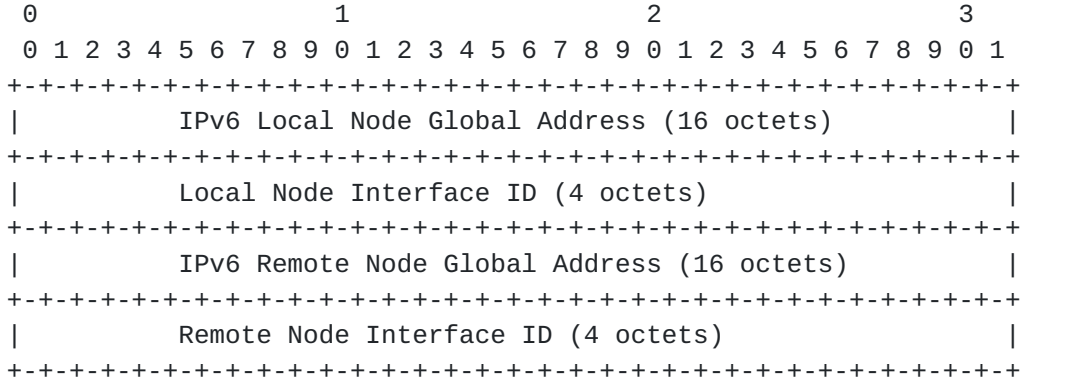
Where:

- IPv4 Local Address: 4 octet value which carries the local IPv4 address associated with the node

- IPv4 Remote Address: 4 octet value which carries the remote IPv4 address associated with the node's neighbor. This is optional and MAY be set to 0 when not used (e.g. when identifying point-to-point links).

6.6.1.7. Type 7: SR-MPLS Adjacency SID for IPv6 with interface ID

The Segment is SR-MPLS Adjacency SID type and is specified as a pair of IPv6 global address and interface ID for local and remote nodes. The format of its Segment Descriptor is as follows:



Where:

- IPv6 Local Node Global Address: 16 octet value which carries the IPv6 global address associated with the local node

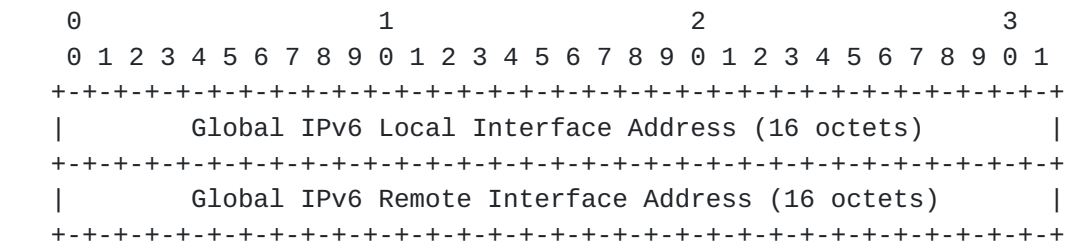
- Local Node Interface ID : 4 octet value which carries the interface ID of the local node identified by the Local Node Address

- IPv6 Remote Node Global Address: 16 octet value which carries the IPv6 global address associated with the remote node. This is optional and MAY be set to 0 when not used (e.g. when identifying point-to-point links).

- Remote Node Interface ID : 4 octet value which carries the interface ID of the remote node identified by the Remote Node Address. This is optional and MAY be set to 0 when not used (e.g. when identifying point-to-point links).

6.6.1.8. Type 8: SR-MPLS Adjacency SID for IPv6 with interface address

The Segment is SR-MPLS Adjacency SID type and is specified as a pair of IPv6 Global addresses for local and remote interface addresses. The format of its Segment Descriptor is as follows:



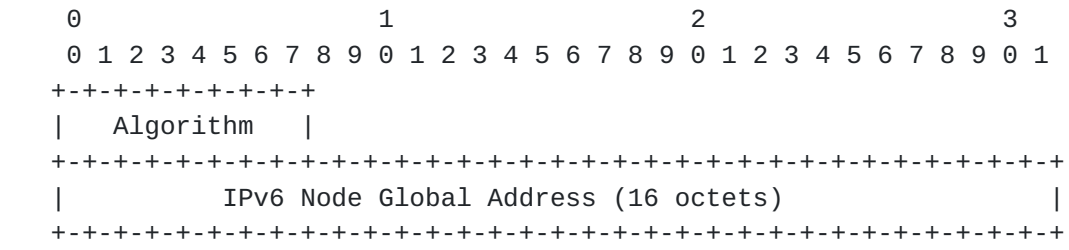
Where:

- IPv6 Local Address: 16 octet value which carries the local IPv6 address associated with the node

- IPv6 Remote Address: 16 octet value which carries the remote IPv6 address associated with the node's neighbor

6.6.1.9. Type 9: SRv6 END SID as IPv6 Node Address

The Segment is SRv6 END SID type and is specified as an IPv6 global address. The format of its Segment Descriptor is as follows:



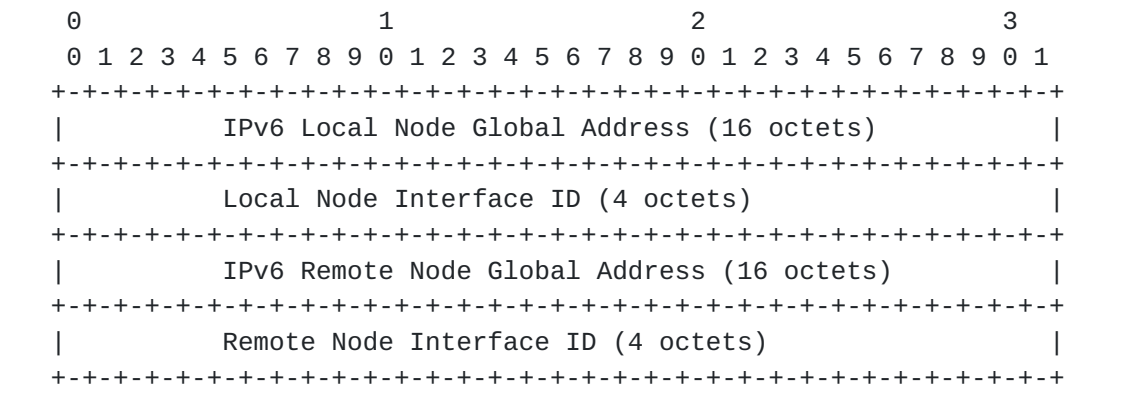
Where:

- Algorithm: 1 octet value that indicates the algorithm used for picking the SID

- IPv6 Node Global Address: 16 octet value which carries the IPv6 global address associated with the node

6.6.1.10. Type 10: SRv6 END.X SID as interface ID

The Segment is SRv6 END.X SID type and is specified as a pair of IPv6 global address and interface ID for local and remote nodes. The format of its Segment Descriptor is as follows:



Where:

- IPv6 Local Node Global Address: 16 octet value which carries the IPv6 global address associated with the local node

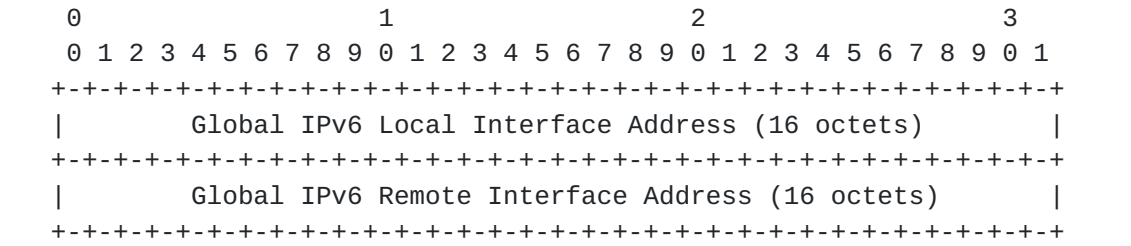
- Local Node Interface ID : 4 octet value which carries the interface ID of the local node identified by the Local Node Address

- IPv6 Remote Node Global Address: 16 octet value which carries the IPv6 global address associated with the remote node. This is optional and MAY be set to 0 when not used (e.g. when identifying point-to-point links).

- Remote Node Interface ID : 4 octet value which carries the interface ID of the remote node identified by the Remote Node Address. This is optional and MAY be set to 0 when not used (e.g. when identifying point-to-point links).

6.6.1.11. Type 11: SRv6 END.X SID as interface address

The Segment is SRv6 END.X SID type and is specified as a pair of IPv6 Global addresses for local and remote interface addresses. The format of its Segment Descriptor is as follows:



Where:

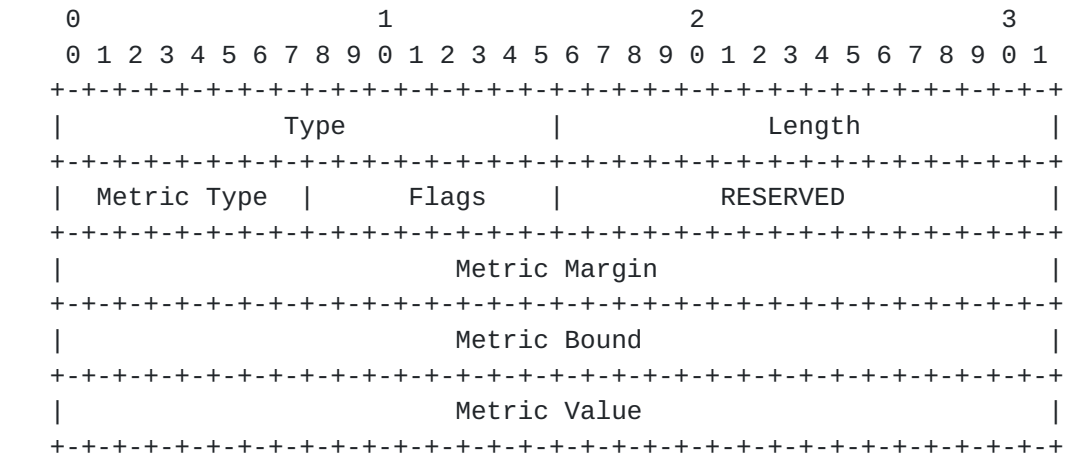
- IPv6 Local Address: 16 octet value which carries the local IPv6 address associated with the node

- IPv6 Remote Address: 16 octet value which carries the remote IPv6 address associated with the node's neighbor

6.7. SR Segment List Metric

The SR Segment List Metric sub-TLV describes the metric used for computation of the SID-List. It is used to report the type of metric used in the computation of a dynamic path either on the headend or when the path computation is delegated to a PCE/controller. When the path computation is done on the headend, it is also used to report the calculated metric for the path.

It is a sub-TLV of the SR Segment List TLV and has following format:



where:

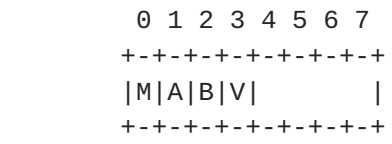
- Type: 1207

- Length: 16 octets

- Metric Type : 1 octet field which identifies the type of metric used for path computation. Following metric type codepoints are defined in this document.

Code Point	Metric Type
0	IGP Metric
1	Min Unidirectional Link Delay [RFC7471]
2	TE Metric [RFC3630]

- Flags: 1 octet field that indicates the validity of the metric fields and their semantics. The following bit positions are defined and the other bits SHOULD be cleared by originator and MUST be ignored by receiver.



where:

  - M-Flag : Indicates that the metric margin allowed for path computation is specified when set

  - A-Flag : Indicates that the metric margin is specified as an absolute value when set and is expressed as a percentage of the minimum metric when clear.

  - B-Flag : Indicates that the metric bound allowed for the path is specified when set.

  - V-Flag : Indicates that the metric value computed is being reported when set.

- RESERVED: 2 octets. SHOULD be set to 0 by originator and MUST be ignored by receiver.

- Metric Margin : 4 octets which indicate the metric margin value when M-flag is set. The metric margin is specified as either an absolute value or as a percentage of the minimum computed path metric based on the A-flag. The metric margin loosens the criteria for minimum metric path calculation up to the specified metric to accomodate for other factors such as bandwidth availability, minimal SID stack depth and maximizing of ECMP for the SR path computed.

- Metric Bound : 4 octects which indicate the maximum metric value that is allowed when B-flag is set. If the computed path metric crosses the specified bound value then the path is considered as invalid.

- Metric Value : 4 octets which indicate the metric value of the computed path when V-flag is set. This value is available and reported when the computation is successful and a valid path is available.

7. Procedures

The BGP-LS advertisements for the TE Policy NLRI are originated by the headend node for the TE Policies that are instantiated on its local node.

For MPLS TE LSPs signaled via RSVP-TE, the NLRI descriptor TLVs as specified in Section 4.1, Section 4.2, Section 4.3 and Section 4.4 are used. Then the TE LSP state is encoded in the BGP-LS Attribute field as MPLS-TE Policy State TLV as described in Section 5. The RSVP-TE objects that reflect the state of the LSP are included as defined in Section 5.1. When the TE LSP is setup with the help of PCEP signaling then another MPLS-TE Policy State TLV SHOULD be used to to encode the related PCEP objects corresponding to the LSP as defined in Section 5.2.

For SR Policies, the NLRI descriptor TLV as specified in Section 4.5 is used. An SR Policy candidate path (CP) may be instantiated on the headend node via a local configuration, PCEP or BGP SR Policy signaling and this is indicated via the SR Protocol Origin. Then the SR Policy Candidate Path's attribute and state is encoded in the BGP-LS Attribute field as SR Policy State TLVs and sub-TLVs as described in Section 6. The SR Candidate Path State TLV as defined in Section 6.2 is included to report the state of the CP. The SR BSID TLV as defined in Section 6.1 is included to report the BSID of the CP when one is either provisioned or allocated by the headend. The constraints for the SR Policy Candidate Path are reported using the SR Candidate Path Constraints TLV as described in Section 6.4.The SR Segment List TLV is included for each of the SID-List(s) associated with the CP. Each SR Segment List TLV in turn includes SR Segment sub-TLV(s) to report the segment(s) and their status. The SR Segment List Metric sub-TLV is used to report the metric values and constraints for the specific SID List.

When the SR Policy CP is setup with the help of PCEP signaling then another MPLS-TE Policy State TLV MAY be used to to encode the related PCEP objects corresponding to the LSP as defined in Section 5.2 specifically to report information and status that is not covered by the defined TLVs under Section 6. In the event of a conflict of information, the receiver MUST prefer the information originated via TLVs defined in Section 6 over the PCEP objects reported via the TE Policy State TLV.

8. Manageability Considerations

The Existing BGP operational and management procedures apply to this document. No new procedures are defined in this document. The considerations as specified in [RFC7752] apply to this document.

In general, it is assumed that the TE Policy head-end nodes are responsible for the distribution of TE Policy state information, while other nodes, e.g. the nodes in the path of a policy, MAY report the TE Policy information (if available) when needed. For example, the border routers in the inter-domain case will also distribute LSP state information since the ingress node may not have the complete information for the end-to-end path.

9. IANA Considerations

This document requires new IANA assigned codepoints.

9.1. BGP-LS NLRI-Types

IANA maintains a registry called "Border Gateway Protocol - Link State (BGP-LS) Parameters" with a sub-registry called "BGP-LS NLRI-Types".

The following codepoints have been assigned by early allocation process by IANA:

Type	NLRI Type	Reference
5	TE Policy NLRI type	this document

9.2. BGP-LS Protocol-IDs

IANA maintains a registry called "Border Gateway Protocol - Link State (BGP-LS) Parameters" with a sub-registry called "BGP-LS Protocol-IDs".

The following Protocol-ID codepoints have been assigned by early allocation process by IANA:

Protocol-ID	NLRI information source protocol	Reference
8	RSVP-TE	this document
9	Segment Routing	this document

9.3. BGP-LS TLVs

IANA maintains a registry called "Border Gateway Protocol - Link State (BGP-LS) Parameters" with a sub-registry called "Node Anchor, Link Descriptor and Link Attribute TLVs".

The following TLV codepoints have been assigned by early allocation process by IANA:

TLV Code Point	Description	Value defined in
550	Tunnel ID TLV	this document
551	LSP ID TLV	this document
552	IPv4/6 Tunnel Head-end address TLV	this document
553	IPv4/6 Tunnel Tail-end address TLV	this document
554	SR Policy CP Descriptor TLV	this document
555	MPLS Local Cross Connect TLV	this document
556	MPLS Cross Connect Interface TLV	this document
557	MPLS Cross Connect FEC TLV	this document
1200	MPLS-TE Policy State TLV	this document
1201	SR BSID TLV	this document
1202	SR CP State TLV	this document
1203	SR CP Name TLV	this document
1204	SR CP Constraints TLV	this document
1205	SR Segment List TLV	this document
1206	SR Segment sub-TLV	this document
1207	SR Segment List Metric sub-TLV	this document
1208	SR Affinity Constraint sub-TLV	this document
1209	SR SRLG Constraint sub-TLV	this document
1210	SR Bandwidth Constraint sub-TLV	this document
1211	SR Disjoint Group Constraint sub-TLV	this document

9.4. BGP-LS SR Policy Protocol Origin

This document requests IANA to maintain a new sub-registry under "Border Gateway Protocol - Link State (BGP-LS) Parameters". The new registry is called "SR Policy Protocol Origin" and contains the codepoints allocated to the "Protocol Origin" field defined in Section 4.5. The registry contains the following codepoints, with initial values, to be assigned by IANA:

Code Point	Protocol Origin
1	PCEP
2	BGP SR Policy
3	Local (via CLI, Yang model through NETCONF, gRPC, etc.)

9.5. BGP-LS TE State Object Origin

This document requests IANA to maintain a new sub-registry under "Border Gateway Protocol - Link State (BGP-LS) Parameters". The new registry is called "TE State Path Origin" and contains the codepoints allocated to the "Object Origin" field defined in Section 5. The registry contains the following codepoints, with initial values, to be assigned by IANA:

Code Point	Object Origin
1	RSVP-TE
2	PCEP
3	Local/Static

9.6. BGP-LS TE State Address Family

This document requests IANA to maintain a new sub-registry under "Border Gateway Protocol - Link State (BGP-LS) Parameters". The new registry is called "TE State Address Family" and contains the codepoints allocated to the "Address Family" field defined in Section 5. The registry contains the following codepoints, with initial values, to be assigned by IANA:

Code Point	Address Family
1	MPLS-IPv4
2	MPLS-IPv6

9.7. BGP-LS SR Segment Descriptors

This document requests IANA to maintain a new sub-registry under "Border Gateway Protocol - Link State (BGP-LS) Parameters". The new registry is called "SR Segment Descriptor Types" and contains the codepoints allocated to the "Segment Type" field defined in Section 6.6 and described in Section 6.6.1. The registry contains the following codepoints, with initial values, to be assigned by IANA:

Code Point	Segment Description
0	Invalid
1	SR-MPLS Label
2	SRv6 SID as IPv6 address
3	SR-MPLS Prefix SID as IPv4 Node Address
4	SR-MPLS Prefix SID as IPv6 Node Global Address
5	SR-MPLS Adjacency SID as IPv4 Node Address & Local Interface ID
6	SR-MPLS Adjacency SID as IPv4 Local & Remote Interface Addresses
7	SR-MPLS Adjacency SID as pair of IPv6 Global Address & Interface ID for Local & Remote nodes
8	SR-MPLS Adjacency SID as pair of IPv6 Global Addresses for the Local & Remote Interface
9	SRv6 END SID as IPv6 Node Global Address
10	SRv6 END.X SID as pair of IPv6 Global Address & Interface ID for Local & Remote nodes
11	SRv6 END.X SID as pair of IPv6 Global Addresses for the Local & Remote Interface

9.8. BGP-LS Metric Type

This document requests IANA to maintain a new sub-registry under "Border Gateway Protocol - Link State (BGP-LS) Parameters". The new registry is called "Metric Type" and contains the codepoints allocated to the "metric type" field defined in Section 6.7. The registry contains the following codepoints, with initial values, to be assigned by IANA:

Code Point	Metric Type
0	IGP Metric
1	Min Unidirectional Link Delay [RFC7471]
2	TE Metric [RFC3630]

10. Security Considerations

Procedures and protocol extensions defined in this document do not affect the BGP security model. See [RFC6952] for details.

11. Contributors

The following people have substantially contributed to the editing of this document:

Clarence Filsfils
Cisco Systems
Email: cfilsfil@cisco.com

12. Acknowledgements

The authors would like to thank Dhruv Dhody, Mohammed Abdul Aziz Khalid, Lou Berger, Acee Lindem, Siva Sivabalan, Arjun Sreekantiah, and Dhanendra Jain for their review and valuable comments.

13. References

13.1. Normative References

[I-D.ietf-idr-bgpls-segment-routing-epe]
Previdi, S., Talaulikar, K., Filsfils, C., Patel, K., Ray, S., and J. Dong, "BGP-LS extensions for Segment Routing BGP Egress Peer Engineering", draft-ietf-idr-bgpls-segment-routing-epe-19 (work in progress), May 2019.

[I-D.ietf-spring-segment-routing-policy]
Filsfils, C., Sivabalan, S., Voyer, D., Bogdanov, A., and P. Mattes, "Segment Routing Policy Architecture", draft-ietf-spring-segment-routing-policy-06 (work in progress), December 2019.

[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>.

[RFC2205] Braden, R., Ed., Zhang, L., Berson, S., Herzog, S., and S. Jamin, "Resource ReSerVation Protocol (RSVP) -- Version 1 Functional Specification", RFC 2205, DOI 10.17487/RFC2205, September 1997, <https://www.rfc-editor.org/info/rfc2205>.

[RFC3209] Awduche, D., Berger, L., Gan, D., Li, T., Srinivasan, V., and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP Tunnels", RFC 3209, DOI 10.17487/RFC3209, December 2001, <https://www.rfc-editor.org/info/rfc3209>.

[RFC3473] Berger, L., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Extensions", RFC 3473, DOI 10.17487/RFC3473, January 2003, <https://www.rfc-editor.org/info/rfc3473>.

[RFC4090] Pan, P., Ed., Swallow, G., Ed., and A. Atlas, Ed., "Fast Reroute Extensions to RSVP-TE for LSP Tunnels", RFC 4090, DOI 10.17487/RFC4090, May 2005, <https://www.rfc-editor.org/info/rfc4090>.

[RFC4760] Bates, T., Chandra, R., Katz, D., and Y. Rekhter, "Multiprotocol Extensions for BGP-4", RFC 4760, DOI 10.17487/RFC4760, January 2007, <https://www.rfc-editor.org/info/rfc4760>.

[RFC4872] Lang, J., Ed., Rekhter, Y., Ed., and D. Papadimitriou, Ed., "RSVP-TE Extensions in Support of End-to-End Generalized Multi-Protocol Label Switching (GMPLS) Recovery", RFC 4872, DOI 10.17487/RFC4872, May 2007, <https://www.rfc-editor.org/info/rfc4872>.

[RFC4873] Berger, L., Bryskin, I., Papadimitriou, D., and A. Farrel, "GMPLS Segment Recovery", RFC 4873, DOI 10.17487/RFC4873, May 2007, <https://www.rfc-editor.org/info/rfc4873>.

[RFC4874] Lee, CY., Farrel, A., and S. De Cnodder, "Exclude Routes - Extension to Resource ReserVation Protocol-Traffic Engineering (RSVP-TE)", RFC 4874, DOI 10.17487/RFC4874, April 2007, <https://www.rfc-editor.org/info/rfc4874>.

[RFC5420] Farrel, A., Ed., Papadimitriou, D., Vasseur, JP., and A. Ayyangar, "Encoding of Attributes for MPLS LSP Establishment Using Resource Reservation Protocol Traffic Engineering (RSVP-TE)", RFC 5420, DOI 10.17487/RFC5420, February 2009, <https://www.rfc-editor.org/info/rfc5420>.

[RFC5440] Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation Element (PCE) Communication Protocol (PCEP)", RFC 5440, DOI 10.17487/RFC5440, March 2009, <https://www.rfc-editor.org/info/rfc5440>.

[RFC7752] Gredler, H., Ed., Medved, J., Previdi, S., Farrel, A., and S. Ray, "North-Bound Distribution of Link-State and Traffic Engineering (TE) Information Using BGP", RFC 7752, DOI 10.17487/RFC7752, March 2016, <https://www.rfc-editor.org/info/rfc7752>.

[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>.

13.2. Informative References

[RFC2702] Awduche, D., Malcolm, J., Agogbua, J., O'Dell, M., and J. McManus, "Requirements for Traffic Engineering Over MPLS", RFC 2702, DOI 10.17487/RFC2702, September 1999, <https://www.rfc-editor.org/info/rfc2702>.

[RFC3630] Katz, D., Kompella, K., and D. Yeung, "Traffic Engineering (TE) Extensions to OSPF Version 2", RFC 3630, DOI 10.17487/RFC3630, September 2003, <https://www.rfc-editor.org/info/rfc3630>.

[RFC4202] Kompella, K., Ed. and Y. Rekhter, Ed., "Routing Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4202, DOI 10.17487/RFC4202, October 2005, <https://www.rfc-editor.org/info/rfc4202>.

[RFC4655] Farrel, A., Vasseur, J., and J. Ash, "A Path Computation Element (PCE)-Based Architecture", RFC 4655, DOI 10.17487/RFC4655, August 2006, <https://www.rfc-editor.org/info/rfc4655>.

[RFC5065] Traina, P., McPherson, D., and J. Scudder, "Autonomous System Confederations for BGP", RFC 5065, DOI 10.17487/RFC5065, August 2007, <https://www.rfc-editor.org/info/rfc5065>.

[RFC6952] Jethanandani, M., Patel, K., and L. Zheng, "Analysis of BGP, LDP, PCEP, and MSDP Issues According to the Keying and Authentication for Routing Protocols (KARP) Design Guide", RFC 6952, DOI 10.17487/RFC6952, May 2013, <https://www.rfc-editor.org/info/rfc6952>.

[RFC7308] Osborne, E., "Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE)", RFC 7308, DOI 10.17487/RFC7308, July 2014, <https://www.rfc-editor.org/info/rfc7308>.

[RFC7471] Giacalone, S., Ward, D., Drake, J., Atlas, A., and S. Previdi, "OSPF Traffic Engineering (TE) Metric Extensions", RFC 7471, DOI 10.17487/RFC7471, March 2015, <https://www.rfc-editor.org/info/rfc7471>.

[RFC8231] Crabbe, E., Minei, I., Medved, J., and R. Varga, "Path Computation Element Communication Protocol (PCEP) Extensions for Stateful PCE", RFC 8231, DOI 10.17487/RFC8231, September 2017, <https://www.rfc-editor.org/info/rfc8231>.

Authors' Addresses

Stefano Previdi

Email: stefano@previdi.net

Ketan Talaulikar (editor)
Cisco Systems, Inc.
India

Email: ketant@cisco.com

Jie Dong (editor)
Huawei Technologies
Huawei Campus, No. 156 Beiqing Rd.
Beijing 100095
China

Email: jie.dong@huawei.com

Mach(Guoyi) Chen
Huawei Technologies
Huawei Campus, No. 156 Beiqing Rd.
Beijing 100095
China

Email: mach.chen@huawei.com

Hannes Gredler
RtBrick Inc.

Email: hannes@rtbrick.com

Jeff Tantsura
Apstra

Email: jefftant.ietf@gmail.com