

TEAS Working Group
Internet-Draft
Intended status: Experimental
Expires: January 20, 2016

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July 19, 2015

**Domain Subobjects for Resource ReserVation Protocol - Traffic
Engineering (RSVP-TE)
draft-ietf-teas-rsvp-te-domain-subobjects-02**

Abstract

The Resource ReserVation Protocol - Traffic Engineering (RSVP-TE) specification and the Generalized Multiprotocol Label Switching (GMPLS) extensions to RSVP-TE allow abstract nodes and resources to be explicitly included in a path setup. Further Exclude Routes extensions to RSVP-TE allow abstract nodes and resources to be explicitly excluded in a path setup.

This document specifies new subobjects to include or exclude 4-Byte Autonomous System (AS) and Interior Gateway Protocol (IGP) area during path setup.

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[1.](#) Introduction

The RSVP-TE specification [[RFC3209](#)] and the GMPLS extensions to RSVP-TE [[RFC3473](#)] allow abstract nodes and resources to be explicitly included in a path setup using the Explicit Route Object (ERO).

Further Exclude Routes extensions [[RFC4874](#)] allow abstract nodes or resources to be excluded from the whole path using the Exclude Route object (XRO). To exclude certain abstract nodes or resources between a specific pair of abstract nodes present in an ERO, a Explicit Exclusion Route Subobject (EXRS) is used.

[RFC3209] already describes the notion of abstract nodes, where an abstract node is a group of nodes whose internal topology is opaque to the ingress node of the Label Switched Path (LSP). It further defines a subobject for AS, but with a 2-Byte AS number only.

This document extends the notion of abstract nodes by adding new subobjects for IGP Areas and 4-byte AS numbers (as per [[RFC6793](#)]). These subobjects can be included in Explicit Route Object (ERO), Exclude Route Object (XRO) or Explicit Exclusion Route Subobject (EXRS).

In case of per-domain path computation [[RFC5152](#)], where the full path of an inter-domain TE LSP cannot be or is not determined at the ingress node, and signaling message could use domain identifiers. The use of these new subobjects is illustrated in [Appendix A](#).

Further, the domain identifier could simply act as delimiter to specify where the domain boundary starts and ends.

This is a companion document to Path Computation Element Protocol (PCEP) extensions for the domain sequence [[PCE-DOMAIN](#)].

[1.1](#). Scope

The procedures described in this document are experimental. The experiment is intended to enable research for the usage of Domain subobjects for inter-domain path setup. For this purpose this document specify new domain subobjects as well as how they incorporate with existing subobjects.

This document does not change the procedures for handling subobjects in RSVP-TE.

The new subobjects introduced by this document will not be understood by legacy implementations. If one of the subobjects is received in a RSVP-TE object that does not understand it, it will behave as described in [[RFC3209](#)] and [[RFC4874](#)]. Therefore, it is assumed that this experiment will be conducted only when all nodes processing the new subobject form part of the experiment.

When the result of implementation and deployment are available, this document will be updated and refined, and then be moved from Experimental to Standard Track.

It should be noted that there are other ways such as use of boundary node to identify the domain (instead of domain identifier), the mechanism defined in this document is just another tool in the toolkit for the operator.

1.2. Requirements Language

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

2. Terminology

The following terminology is used in this document.

AS: Autonomous System.

Domain: As per [[RFC4655](#)], any collection of network elements within a common sphere of address management or path computational responsibility. Examples of domains include Interior Gateway Protocol (IGP) areas and Autonomous Systems (ASs).

ERO: Explicit Route Object

EXRS: Explicit Exclusion Route Subobject

IGP: Interior Gateway Protocol. Either of the two routing protocols, Open Shortest Path First (OSPF) or Intermediate System to Intermediate System (IS-IS).

IS-IS: Intermediate System to Intermediate System.

OSPF: Open Shortest Path First.

PCE: Path Computation Element. An entity (component, application, or network node) that is capable of computing a network path or route based on a network graph and applying computational constraints.

PCEP: Path Computation Element Protocol.

RSVP: Resource Reservation Protocol

TE LSP: Traffic Engineering Label Switched Path.

XRO: Exclude Route Object

3. Subobjects for Domains

3.1. Domains

[RFC4726] and [RFC4655] define domain as a separate administrative or geographic environment within the network. A domain could be further defined as a zone of routing or computational ability. Under these definitions a domain might be categorized as an AS or an IGP area.

As per [RFC3209], an abstract node is a group of nodes whose internal topology is opaque to the ingress node of the LSP. Using this concept of abstraction, an explicitly routed LSP can be specified as a sequence of IP prefixes or a sequence of Autonomous Systems. In this document we extend the notion to include IGP area and 4-Byte AS number.

These sub-objects appear in RSVP-TE, notably in -

- o Explicit Route Object (ERO): As per [RFC3209], an explicit route is a particular path in the network topology including abstract nodes (including domains).
- o Exclude Route Object (XRO): As per [RFC4874], an exclude route identifies a list of abstract nodes (including domains), that should not be traversed along the path of the LSP being established.
- o Explicit Exclusion Route Subobject (EXRS): As per [RFC4874], used to specify exclusion of certain abstract nodes between a specific pair of nodes. EXRS are a subobject carried inside the ERO. These subobjects can be used to specify the domains to be excluded between two abstract nodes.

3.2. Explicit Route Object (ERO)'s Subobjects

As stated in [RFC3209], an explicit route is a particular path in the network topology. In addition to the ability to identify specific nodes along the path, an explicit route can identify a group of nodes (abstract nodes) to be traversed along the path.

Some subobjects are defined in [RFC3209], [RFC3473], [RFC3477], [RFC4874] and [RFC5553] but new subobjects related to domains are needed.

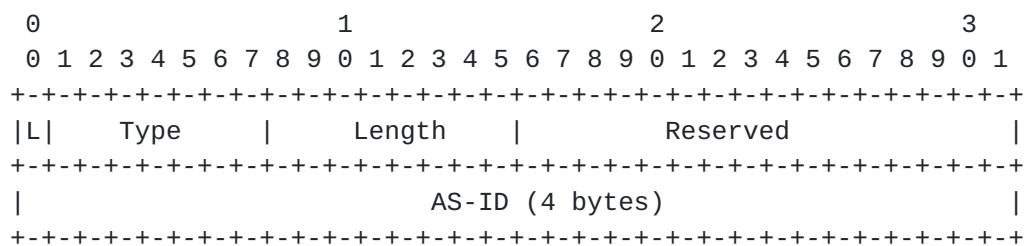
This document extends the support for 4-Byte AS numbers and IGP Areas.

Type	Subobject
TBD1	Autonomous system number (4 Byte)
TBD2	OSPF Area id
TBD3	ISIS Area id

3.2.1. Autonomous system

[RFC3209] already defines 2-Byte AS number.

To support 4-Byte AS numbers as per [RFC6793], the following subobject is defined:



L: The L bit is an attribute of the subobject as defined in [RFC3209], i.e., set if the subobject represents a loose hop in the explicit route. If the bit is not set, the subobject represents a strict hop in the explicit route.

Type: (TBD1 by IANA) indicating a 4-Byte AS Number.

Length: 8 (Total length of the subobject in bytes).

Reserved: Zero at transmission, ignored at receipt.

AS-ID: The 4-Byte AS Number. Note that if 2-Byte AS numbers are in use, the low order bits (16 through 31) MUST be used and the high order bits (0 through 15) MUST be set to zero. For the purpose of this experiment, it is advised to use 4-Byte AS number subobject as default.

3.2.2. IGP Area

Since the length and format of Area-id is different for OSPF and ISIS, the following two subobjects are defined:

For OSPF, the area-id is a 32 bit number. The subobject is encoded as follows:

3.2.3. Mode of Operation

The new subobjects to support 4-Byte AS and IGP (OSPF / ISIS) Area could be used in the ERO to specify an abstract node (a group of nodes whose internal topology is opaque to the ingress node of the LSP).

All the rules of processing (for example Next Hop Selection, L bit processing, unrecognized subobjects etc) are as per the [\[RFC3209\]](#). Note that if a node is called upon to process subobject defined in this document, and it does not recognize, it will behave as described in [\[RFC3209\]](#) when an unrecognized ERO subobject is encountered. This means that this node will return a PathErr with error code "Routing Error" and error value "Bad EXPLICIT_ROUTE object" with the EXPLICIT_ROUTE object included, truncated (on the left) to the offending subobject.

3.3. Exclude Route Object (XRO)'s Subobjects

As stated in [\[RFC4874\]](#), the exclude route identifies a list of abstract nodes that to exclude (not be traversed) along the path of the LSP being established.

Some subobjects are defined in [\[RFC3209\]](#), [\[RFC3477\]](#), [\[RFC4874\]](#) and [\[RFC6001\]](#) but new subobjects related to domains are needed.

This document extends the support for 4-Byte AS numbers and IGP Areas.

Type	Subobject
TBD1	Autonomous system number (4 Byte)
TBD2	OSPF Area id
TBD3	ISIS Area id

3.3.1. Autonomous system

[\[RFC3209\]](#) and [\[RFC4874\]](#) already define a 2-Byte AS number.

To support 4-Byte AS numbers as per [\[RFC6793\]](#), a subobject is with the same format as defined in [Section 3.2.1](#) with following difference:

The meaning of the L bit is as per [\[RFC4874\]](#), where.

0: indicates that the abstract node specified MUST be excluded.

1: indicates that the abstract node specified SHOULD be avoided.

3.3.2. IGP Area

Since the length and format of Area-id is different for OSPF and ISIS, the following two subobjects are defined:

For OSPF, the area-id is a 32 bit number. Subobjects for OSPF and IS-IS are of the same format as defined in [Section 3.2.2](#) with following difference:

The meaning of the L bit is as per [\[RFC4874\]](#).

3.3.3. Mode of Operation

The new subobjects to support 4-Byte AS and IGP (OSPF / ISIS) Area could also be used in the XRO to specify exclusion of an abstract node (a group of nodes whose internal topology is opaque to the ingress node of the LSP).

All the rules of processing are as per the [\[RFC4874\]](#).

Note that if a node is called upon to process a subobject defined in this document, and it does not recognize, it will behave as described in [\[RFC4874\]](#) when an unrecognized XRO subobject is encountered, i.e. to ignore it. In this case the desired exclusion will not be carried out.

3.4. Explicit Exclusion Route Subobject

As per [\[RFC4874\]](#), the Explicit Exclusion Route is used to specify exclusion of certain abstract nodes between a specific pair of nodes or resources in the explicit route. EXRS is an ERO subobject that contains one or more subobjects of its own, called EXRS subobjects.

The EXRS subobject could carry any of the subobjects defined for XRO, thus the new subobjects to support 4-Byte AS and IGP (OSPF / ISIS) Area can also be used in the EXRS. The meanings of the fields of the new XRO subobjects are unchanged when the subobjects are included in an EXRS, except that scope of the exclusion is limited to the single hop between the previous and subsequent elements in the ERO.

All the rules of processing are as per the [\[RFC4874\]](#).

4. Interaction with Path Computation Element (PCE)

The domain subobjects to be used in Path Computation Element Protocol (PCEP) are referred to in [\[PCE-DOMAIN\]](#). Note that the new domain subobjects follow the principle that subobjects used in PCEP

[RFC5440] are identical to the subobjects used in RSVP-TE and thus are interchangeable between PCEP and RSVP-TE.

5. IANA Considerations

5.1. New Subobjects

IANA maintains the "Resource Reservation Protocol (RSVP) Parameters" at <http://www.iana.org/assignments/rsvp-parameters/rsvp-parameters.xhtml>. Within this registry IANA maintains two sub-registries:

- o "EXPLICIT_ROUTE subobjects": <http://www.iana.org/assignments/rsvp-parameters/rsvp-parameters.xhtml#rsvp-parameters-25>
- o "EXCLUDE_ROUTE subobjects": <http://www.iana.org/assignments/rsvp-parameters/rsvp-parameters.xhtml#rsvp-parameters-95>

Upon approval of this document, IANA is requested to make identical additions to these registries as follows, in sync with [[PCE-DOMAIN](#)]:

Subobject	Type	Reference
TBD1	4-Byte AS number	[This I.D.]
TBD2	OSPF Area ID	[This I.D.]
TBD3	IS-IS Area ID	[This I.D.]

6. Security Considerations

Security considerations for MPLS-TE and GMPLS signaling are covered in [[RFC3209](#)] and [[RFC3473](#)]. This document does not introduce any new messages or any substantive new processing, and so those security considerations continue to apply. Further, general considerations for securing RSVP-TE in MPLS-TE and GMPLS networks can be found in [[RFC5920](#)].

The route exclusion security consideration are covered in [[RFC4874](#)] and continue to apply.

7. Acknowledgments

We would like to thank Adrian Farrel, Lou Berger, George Swallow, Chirag Shah, Reeya Paul, Sandeep Boina and Avantika for their useful comments and suggestions.

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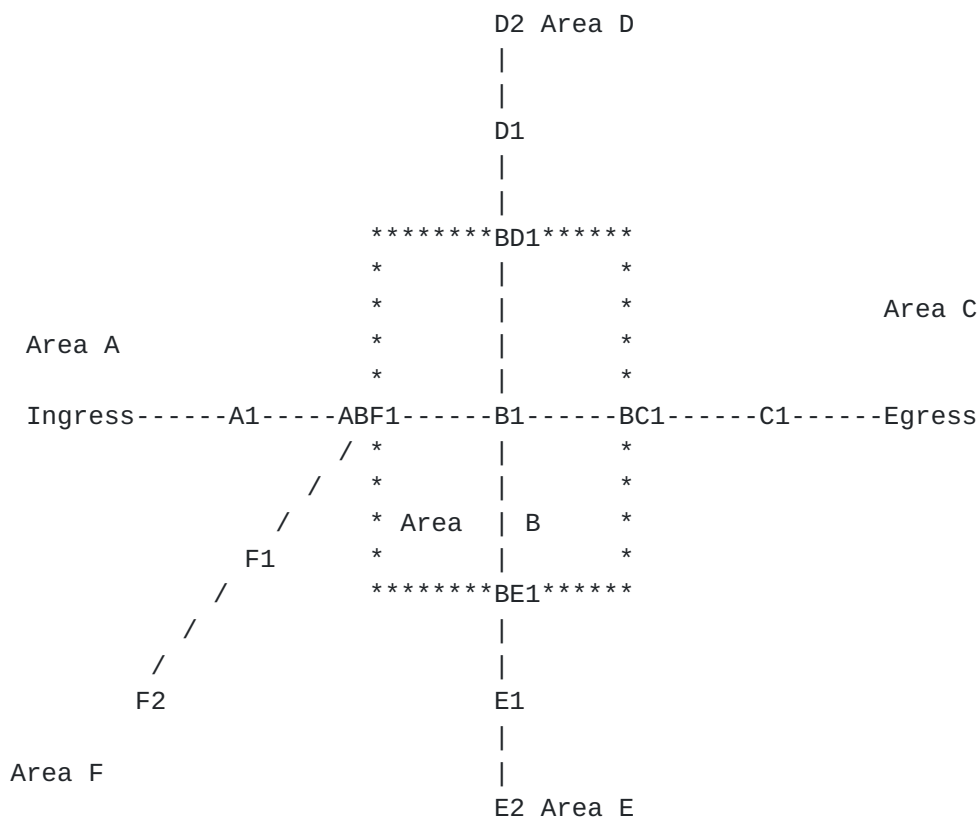
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Appendix A. Examples

These examples are for illustration purposes only, to show how the new subobjects could be encoded. They are not meant to be an exhaustive list of all possible usecases and combinations.

A.1. Inter-Area LSP Path Setup

In an inter-area LSP path setup where the ingress and the egress belong to different IGP areas within the same AS, the domain subobjects could be represented using an ordered list of IGP area subobjects in an ERO.



* All IGP Area in one AS (AS 100)

Figure 1: Domain Corresponding to IGP Area

As per Figure 1, the signaling at Ingress could be -

ERO:(A1, ABF1, Area B, Area C, Egress)

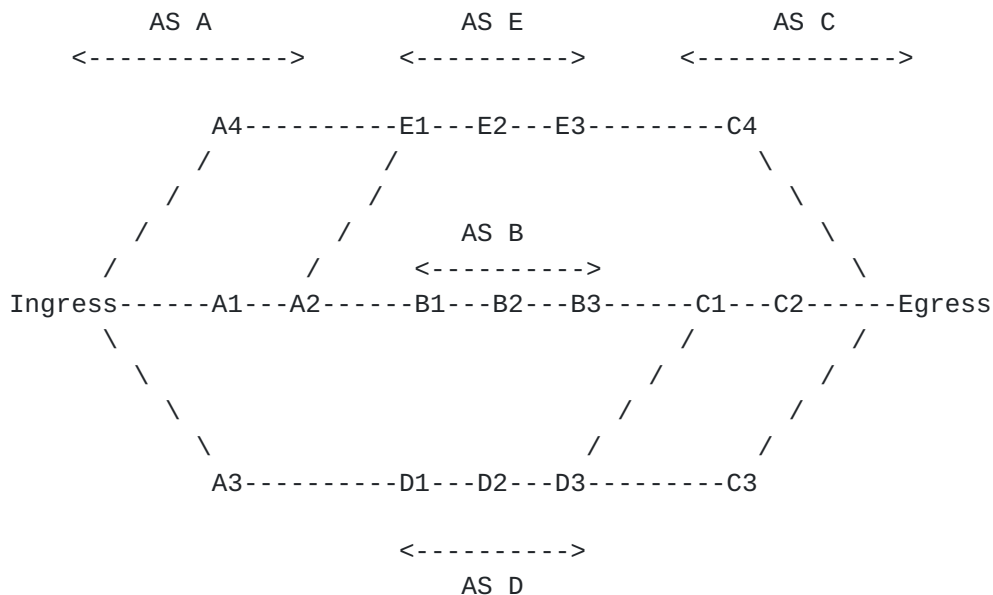
It should be noted that there are other ways to achieve the desired signaling, the area subobject provides another tool in the toolkit and can have operational benefits when -

- o Use of PCEP like domain-sequence [[PCE-DOMAIN](#)] configurations in explicit path such that area subobjects can be used to signal the loose path.
- o Alignment of subobjects and registries between PCEP and RSVP-TE, thus allowing easier interworking between path computation and signaling i.e. to and fro of subobjects between signalling and path computation (if need be).

[A.2.](#) Inter-AS LSP Path Setup

[A.2.1.](#) Example 1

In an inter-AS LSP path setup where the ingress and the egress belong to different AS, the domain subobjects (AS) could be used in an ERO.



* All AS have one area (area 0)

Figure 2: Domain Corresponding to AS

As per Figure 2, the signaling at Ingress could be -

ERO:(A1, A2, AS B, AS C, Egress); or

ERO:(A1, A2, AS B, Area 0, AS C, Area 0, Egress).

Each AS has a single IGP area (area 0), Area subobject is optional.

Note that to get a domain disjoint path, the ingress could also signal the backup path with -

XRO:(AS B)

[A.2.2.](#) **Example 2**

As shown in Figure 3, where AS 200 is made up of multiple areas, the signaling can include both AS and Area subobject to uniquely identify a domain.

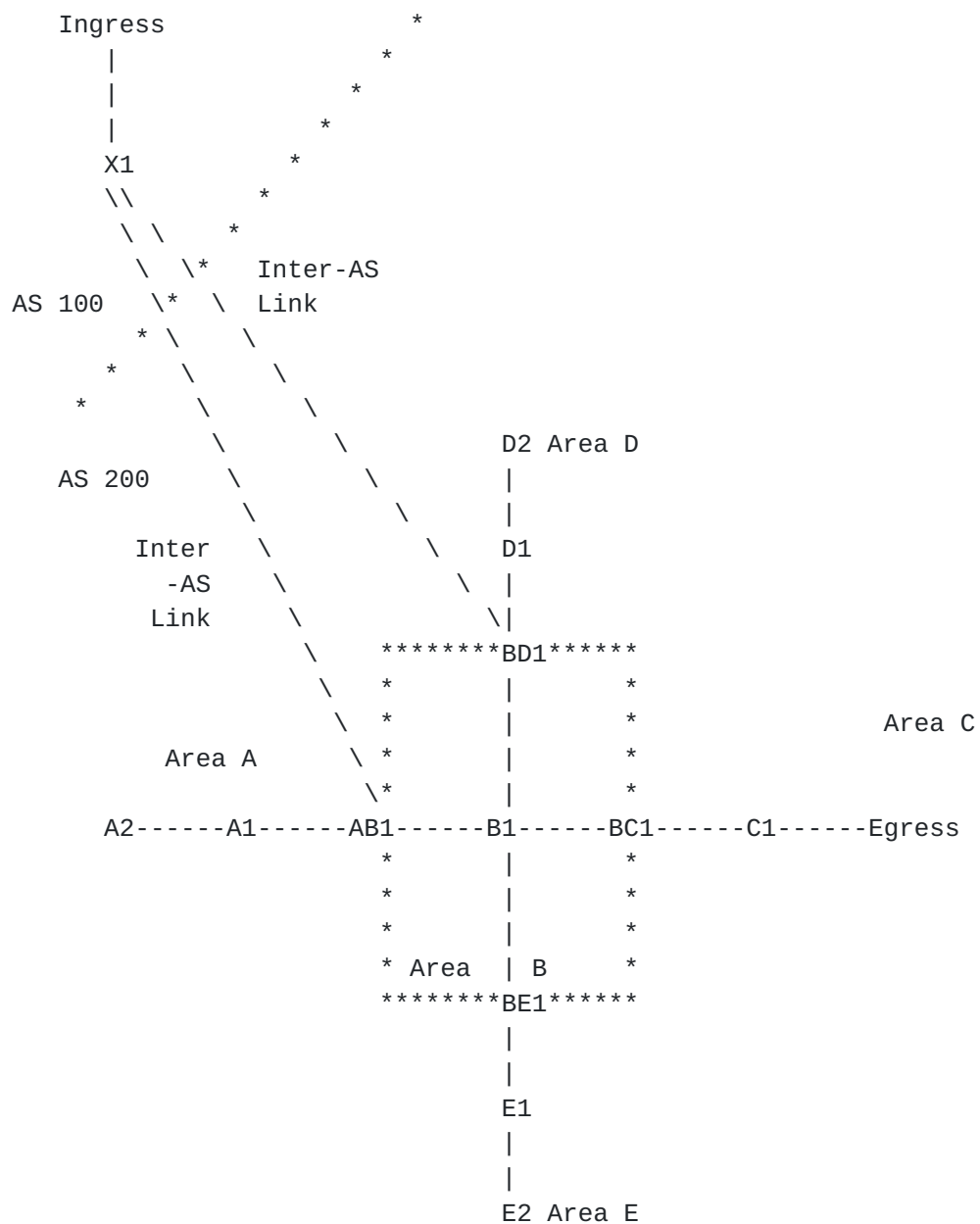


Figure 3: Domain Corresponding to AS and Area

As per Figure 3, the signaling at Ingress could be -

ERO:(X1, AS 200, Area B, Area C, Egress).

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