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Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Path  
Diversity using Exclude Route

[draft-ietf-ccamp-lsp-diversity-03.txt](#)

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## Abstract

[RFC 4874](#) specifies methods by which path exclusions may be communicated during RSVP-TE signaling in networks where precise explicit paths are not computed by the LSP source node. This document specifies signaling for additional route exclusion subobjects based on Paths currently existing or expected to exist within the network.

## Conventions used in this document

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

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## [1.](#) Introduction

Path diversity is a well-known requirement from Service Providers. Such diversity ensures Label-Switched Paths (LSPs) may be established without sharing resources, thus greatly reducing the probability of simultaneous connection failures.

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When a source node has full topological knowledge and is permitted to signal an Explicit Route Object, diverse paths can be computed locally. However, there are scenarios when path computations are performed by remote nodes, thus there is a need for relevant diversity requirements to be communicated to those nodes. These include (but are not limited to):

- . LSPs with loose hops in the Explicit Route Object (ERO), e.g. inter-domain LSPs;
- . Generalized Multi-Protocol Label Switching (GMPLS) User-Network Interface (UNI) where path computation may be performed by the (server layer) core node [[RFC4208](#)].

[RFC4874] introduced a means of specifying nodes and resources to be excluded from a route, using the eXclude Route Object (XRO) and Explicit Exclusion Route Subobject (EXRS).

[RFC4874] facilitates the calculation of diverse paths for LSPs based on known properties of those paths including addresses of links and nodes traversed, and Shared Risk Link Groups (SRLGs) of traversed links. Employing these mechanisms requires that the source node that initiates signaling knows the relevant properties of the path(s) from which diversity is desired. However, there are circumstances under which this may not be possible or desirable, including (but not limited to):

- . Exclusion of a path which does not originate, terminate or traverse the source node signaling the diverse LSP, in which case the addresses and SRLGs of the path from which diversity is required are unknown to the source node.
- . Exclusion of a path which is known to the source node of the diverse LSP, however the node has incomplete or no path information, e.g. due to policy. In other words, the scenario in which the reference path is known by the source / requesting node but the properties required to construct an XRO object are not fully known. Inter-domain and GMPLS overlay networks can

present such restrictions.

This document defines procedures that may be used to exclude the path taken by a particular LSP, or the paths taken by all LSPs belonging to a single tunnel. The diversity requirements considered in this document do not require that the paths in question belong to the same tunnel or share the same source or destination node.

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If mutually diverse paths are desired for two LSPs belonging to different tunnels, it is recommended that they be signaled with XRO LSP subobjects referencing each other. The processing rules specified in this document cover this case.

The means by which the node calculating or expanding the route of the signaled LSP discovers the route of the path(s) from which the signaled LSP requires diversity are beyond the scope of this document.

This document addresses only the exclusion of point-to-point paths. Exclusion of point-to-multipoint paths is beyond the scope of this document.

## [2.](#) RSVP-TE signaling extensions

This section describes the signaling extensions required to address the aforementioned requirements. Specifically, this document defines a new LSP subobject to be signaled in the EXCLUDE\_ROUTE object (XRO) and/ or Explicit Exclusion Route Subobject (EXRS) defined in [[RFC4874](#)]. Inclusion of the LSP subobject in any other RSVP object is not defined.

### [2.1.](#) Terminology

In this document, the following terminology is adopted:

**Excluded path:** the path from which diversity is required.

**Diverse LSP:** the LSP being signaled with XRO/ EXRS containing the path subobject referencing the excluded path(s).

**Processing node:** the node performing a path-calculation involving

exclusion specified in an XRO or EXRS.

Destination node: in the context of an XRO, this is the destination of the LSP being signaled. In the context of an EXRS, the destination node is the last explicit node to which the loose hop is expanded.

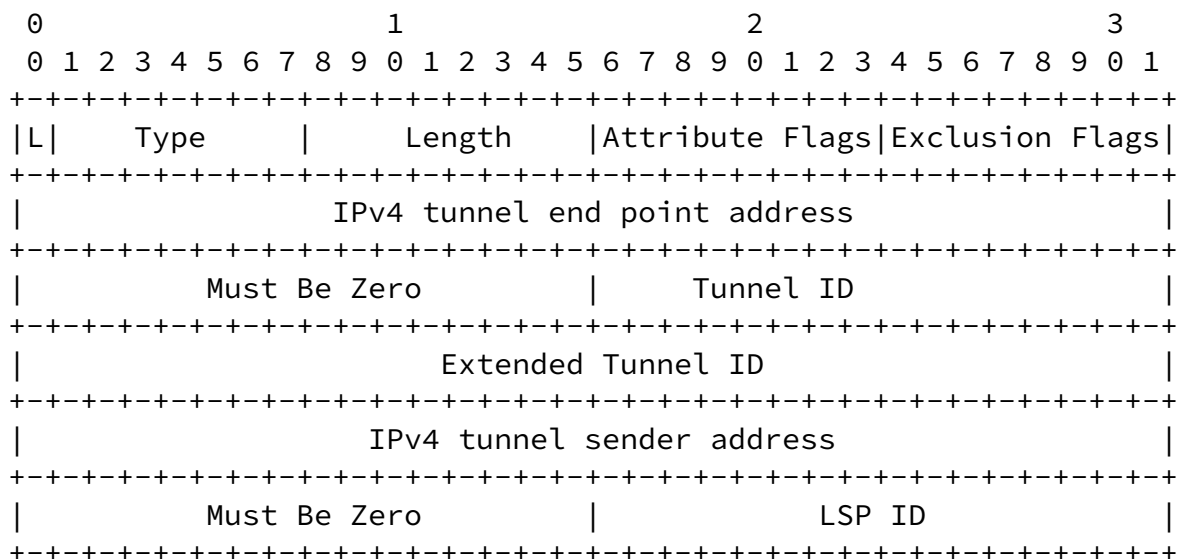
Penultimate node: in the context of an XRO, this is the penultimate hop of the LSP being signaled. In the context of an EXRS, the penultimate node is the penultimate node of the loose hop undergoing expansion.

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## [2.2.](#) Path XRO Subobjects

New IPv4 and IPv6 Point-to-Point (P2P) Path XRO subobjects are defined by this document as follows.

### [2.2.1.](#) IPv4 Point-to-Point Path subobject



L:  
The L-flag is used as for the other XRO subobjects defined

in [[RFC4874](#)].

0 indicates that the attribute specified MUST be excluded.

1 indicates that the attribute specified SHOULD be avoided.

Type:

IPv4 Point-to-Point Path subobject (to be assigned by IANA; suggested value: 36).

Length:

The length contains the total length of the subobject in bytes, including the type and length fields. The length is always 24.

Attribute Flags:

The Attribute Flags are used to communicate desirable attributes of the LSP being signaled. The following flags are defined. Each flag acts independently. Any combination of flags is permitted.

0x01 = LSP ID to be ignored

Indicates tunnel level exclusion. Specifically, this flag is used to indicate that the lsp-id field of the subobject is to be ignored and the exclusion applies to any LSP matching the rest of the supplied FEC.

0x02 = Destination node exception

Indicates that exclusion does not apply to the destination node of the LSP being signaled.

0x04 = Processing node exception

Indicates that exclusion does not apply to the ERO

processing node of the LSP being signaled.

0x08 = Penultimate node exception

Indicates that the penultimate node of the LSP being signaled MAY be shared with the excluded path even when this violates the exclusion flags.

Indicates that exclusion does not apply to the penultimate node of the LSP being signaled.

### Exclusion Flags

The Exclusion-Flags are used to communicate the desired type(s) of exclusion. The following flags are defined.

0x01 = SRLG exclusion

Indicates that the path of the LSP being signaled is requested to be SRLG diverse from the excluded path specified by the LSP subobject.

0x02 = Node exclusion

Indicates that the path of the LSP being signaled is requested to be node diverse from the excluded path specified by the LSP subobject.

(Note: the meaning of this flag may be modified by the value of the Attribute-flags.)

0x04 = Link exclusion

Indicates that the path of the LSP being signaled is requested to be link diverse from the path specified by the LSP subobject.

The remaining fields are as defined in [[RFC3209](#)].

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### 2.2.2. IPv6 Point-to-Point Path subobject

```

      0             1             2             3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|L|  Type  |  Length  |Attribute Flags|Exclusion Flags|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|
|           IPv6 tunnel end point address           |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|           IPv6 tunnel end point address (cont.)   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|           IPv6 tunnel end point address (cont.)   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|           IPv6 tunnel end point address (cont.)   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|           Must Be Zero           |  Tunnel ID           |

```



```

+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Extended Tunnel ID                                     |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Extended Tunnel ID (cont.)                             |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Extended Tunnel ID (cont.)                             |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Extended Tunnel ID (cont.)                             |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     IPv4 tunnel sender address                           |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     IPv4 tunnel sender address (cont.)                   |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     IPv4 tunnel sender address (cont.)                   |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     IPv4 tunnel sender address (cont.)                   |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|          Must Be Zero          |          LSP ID          |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+

```

L

The L-flag is used as for the other XRO subobjects defined in [RFC4874].

0 indicates that the attribute specified MUST be excluded.

1 indicates that the attribute specified SHOULD be avoided.

Type

IPv6 Point-to-Point Path subobject  
(to be assigned by IANA; suggested value: 37).

Length

The length contains the total length of the subobject in bytes, including the type and length fields. The length is always 48.

The Attribute Flags and Exclusion Flags are as defined for the IPv4 Point-to-Point LSP XRO subobject.

The remaining fields are as defined in [[RFC3209](#)].

### [2.3](#). Processing rules for the Path XRO subobjects

XRO processing as described in [[RFC4874](#)] is unchanged.

If the processing node is the destination for the LSP being signaled, it SHOULD NOT process a Path XRO subobject.

If the L-flag is not set, the processing node follows the following procedure:

- The processing node MUST ensure that any path calculated for the signaled LSP respects the requested exclusion flags with respect to the excluded path referenced by the subobject, including local resources.
- If the processing node fails to find a path that meets the requested constraint, the processing node MUST return a PathErr with the error code "Routing Problem" (24) and error sub-code "Route blocked by Exclude Route" (67).
- If the excluded path referenced in the LSP subobject is unknown to the processing node, the processing node SHOULD ignore the LSP subobject in the XRO and SHOULD proceed with the

signaling request. After sending the Resv for the signaled LSP, the processing node SHOULD return a PathErr with the error code "Notify Error" (25) and error sub-code "Route of XRO path unknown" (value to be assigned by IANA, suggested value: 13) for the signaled LSP.

If the L-flag is set, the processing node follows the procedure below:

- The processing node SHOULD respect the requested exclusion flags with respect to the excluded path to the extent possible.
- If the processing node fails to find a path that meets the

requested constraint, it SHOULD proceed with signaling using a suitable path that meets the constraint as far as possible. After sending the Resv for the signaled LSP, it SHOULD return a PathErr message with error code "Notify Error" (25) and error sub-code "Failed to respect Exclude Route" (value: to be assigned by IANA, suggest value: 14) to the source node.

- If the excluded path referenced in the LSP subobject is unknown to the processing node, the processing node SHOULD ignore the LSP subobject in the XRO and SHOULD proceed with the signaling request. After sending the Resv for signaled LSP, the processing node SHOULD return a PathErr message with the error code "Notify Error" (25) and error sub-code "Route of XRO path unknown" for the signaled LSP.

If, subsequent to the initial signaling of a diverse LSP:

- an excluded path referenced in the diverse LSP's XRO subobject becomes known to the processing node (e.g. when the excluded path is signaled), or
- A change in the excluded path becomes known to the processing node,

the processing node SHOULD re-evaluate the exclusion and diversity constraints requested by the diverse LSP to determine whether they are still satisfied.

- If the requested exclusion constraints for the diverse LSP are no longer satisfied and an alternative path for the diverse LSP that can satisfy those constraints exists, the processing node SHOULD send a PathErr message for the diverse LSP with the error code "Notify Error" (25) and a new error sub-code "compliant path exists" (value: to be assigned by IANA, suggest

value: 15). A source node receiving a PathErr message with this error code and sub-code combination MAY try to reoptimize the diverse tunnel to the new compliant path.

- If the requested exclusion constraints for the diverse LSP are no longer satisfied and no alternative path for the diverse LSP that can satisfy those constraints exists, then:

- o If the L-flag was not set in the original exclusion, the processing node MUST send a PathErr message for the diverse LSP with the error code "Routing Problem" (24) and error sub-code "Route blocked by Exclude Route" (67). The PSR flag SHOULD NOT be set.
- o If the L-flag was set in the original exclusion, the processing node SHOULD send a PathErr message for the diverse LSP with the error code error code "Notify Error" (25) and error sub-code "Failed to respect Exclude Route" (value: to be assigned by IANA, suggest value: 14).

The following rules apply whether or not the L-flag is set:

- An XRO object MAY contain multiple path subobjects.
- A source node receiving a PathErr message with the error code "Notify Error" (25) and error sub-codes "Route of XRO path unknown" or "Failed to respect Exclude Route" MAY take no action.
- The attribute-flags affect the processing of the XRO subobject as follows:
  - o When the "LSP ID to be ignored" flag is set, the processing node MUST calculate a path based on exclusions from the paths of all known LSPs matching the tunnel-id, source, destination and extended tunnel-id specified in the subobject (i.e., tunnel level exclusion). When this flag is not set, the lsp-id is not ignored and the exclusion applies only to the specified LSP (i.e., LSP level exclusion).
  - o When the "destination node exception" flag is not set, the exclusion flags SHOULD also be respected for the destination node.

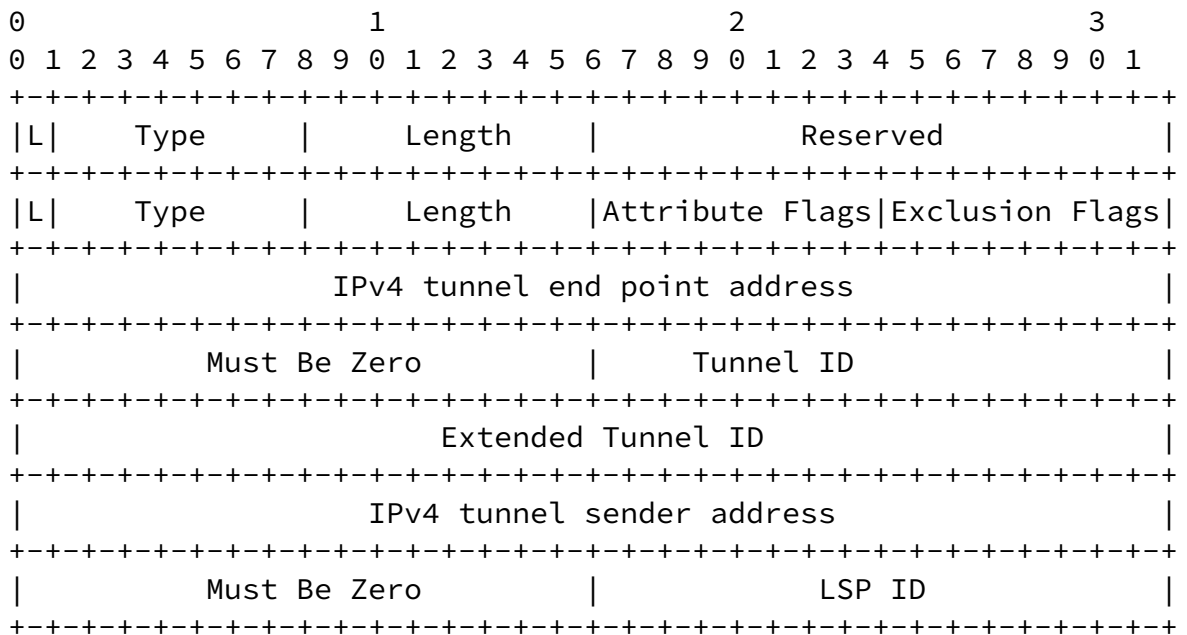
- o When the "processing node exception" flag is not set, the exclusion flags SHOULD also be respected for the processing node.

- o When the "penultimate node exception" flag is not set, the exclusion flags SHOULD also be respected for the penultimate node.

#### 2.4. Path EXRS Subobject

[RFC4874] defines the EXRS ERO subobject. An EXRS is used to identify abstract nodes or resources that must not or should not be used on the path between two inclusive abstract nodes or resources in the explicit route. An EXRS contains one or more subobjects of its own, called EXRS subobjects [RFC4874].

An EXRS MAY include an IPv4 Point-to-Point (P2P) Path subobject as specified in [section 2.2.1](#). In this case, the EXRS format would be as follows:



The meanings of respective fields in EXRS header are as defined in [RFC4874]. The meanings of respective fields in IPv4 P2P Path subobject are as defined earlier in this document.

The processing rules for the EXRS object are unchanged from [RFC4874]. When the EXRS contains one or more Path subobject(s),

the processing rules specified in [Section 2.3](#) apply to the node processing the ERO with the EXRS subobject.

If a loose-hop expansion results in the creation of another loose-hop in the outgoing ERO, the processing node MAY include the EXRS in the newly-created loose hop for further processing by downstream nodes.

The processing node exception for the EXRS subobject applies to the node processing the ERO.

The destination node exception for the EXRS subobject applies to the explicit node identified by the ERO subobject that identifies the next abstract node. This flag is only processed if the L bit is set in the ERO subobject that identifies the next abstract node.

The penultimate node exception for the EXRS subobject applies to the node before the explicit node identified by the ERO subobject that identifies the next abstract node. This flag is only processed if the L bit is set in the ERO subobject that identifies the next abstract node.

### 3. Security Considerations

This document does not introduce any additional security issues above those identified in [\[RFC5920\]](#), [\[RFC2205\]](#), [\[RFC3209\]](#), [\[RFC3473\]](#) and [\[RFC4874\]](#).

### 4. IANA Considerations

#### 4.1. New XRO subobject types

IANA registry: RSVP PARAMETERS

Subsection: Class Names, Class Numbers, and Class Types

This document introduces two new subobjects for the EXCLUDE\_ROUTE object [\[RFC4874\]](#), C-Type 1.

Subobject Type

Subobject Description

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To be assigned by IANA  
(suggested value: 36)

IPv4 P2P Path subobject

To be assigned by IANA  
(suggested value: 37)

IPv6 P2P Path subobject

#### [4.2.](#) New EXRS subobject types

The IPv4 and IPv6 P2P Path subobjects are also defined as new EXRS subobjects.

#### [4.3.](#) New RSVP error sub-codes

IANA registry: RSVP PARAMETERS

Subsection: Error Codes and Globally-Defined Error Value Sub-Codes

For Error Code "Notify Error" (25) (see [[RFC3209](#)]) the following sub-codes are defined.

Sub-code -----	Value -----
Route of XRO path unknown	To be assigned by IANA. Suggested Value: 13.
Failed to respect Exclude Route	To be assigned by IANA. Suggested Value: 14.
Compliant path exists	To be assigned by IANA. Suggested Value: 15.

#### [5.](#) Acknowledgements

The authors would like to thank Luyuan Fang and Walid Wakim for their review comments.

#### [6.](#) References

##### [6.1.](#) Normative References

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## 6.2. Informative References

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- [RFC2205] Braden, R. (Ed.), Zhang, L., Berson, S., Herzog, S. and S. Jamin, "Resource ReserVation Protocol -- Version 1 Functional Specification", [RFC 2205](#), September 1997.
- [RFC5920] Fang, L., Ed., "Security Framework for MPLS and GMPLS Networks", [RFC 5920](#), July 2010.

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