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**Exclude Routes - Extension to RSVP-TE**  
<[draft-lee-ccamp-rsvp-te-exclude-route-02.txt](#)>

## **1. Status of this memo**

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## **2. Abstract**

The current RSVP-TE specification, "RSVP-TE: Extensions to RSVP for LSP Tunnels" ([RFC 3209](#)) and GMPLS extensions to RSVP-TE, "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions" ([RFC 3473](#)) allow abstract nodes and resources to be explicitly included in a path setup, but not to be explicitly excluded.

In some systems where precise explicit paths are not computed at the head end it may be useful to specify and signal abstract nodes and resources that are to be explicitly excluded from routes. These exclusions may apply to the whole of a path, or to parts of a path between two abstract nodes specified in an explicit route.

Shared Risk Link Groups (SRLGs) allow the definition of resources or groups of resources that share the same risk of failure. The knowledge of SRLGs may be used to compute diverse paths that can be used for protection. In systems where it is useful to signal exclusions, it may be useful to signal SRLGs to indicate groups of resources that should be excluded on the whole of a path or between two abstract nodes specified in an explicit path.

This document specifies ways to communicate route exclusions during

path setup using RSVP-TE.

## **2.1 Future Work**

Future work on this document may include the following.

- Addition of further examples and explanation of the applicability of route exclusion.
- reduction of the length of the XRO and EXRS subobjects
- Identification of the scope of relevance of exclusions so that they may be omitted from signaled messages, or at least from path computations, when they are not relevant.
- Exclusion of unnumbered links.
- Convergence of SRLG identification with formats defined in other drafts.

## **3. 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 [[RFC2119](#)].

## **4. Overview**

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

In some systems it may be useful to specify and signal abstract nodes and resources that are to be explicitly excluded from routes. This may be because loose hops or abstract nodes need to be prevented from causing a route through a specific resource. This is a special case of path calculation distribution to nodes within the system.

Two types of exclusions are required:

- i) Do not include any of the abstract nodes in a given set anywhere on the path. This set of abstract nodes to exclude is referred to as the Exclude Route list.
- ii) Do not include certain abstract nodes or resources between a specific pair of abstract nodes present in an ERO. Such specific exclusions are referred to as Explicit Exclusion Route.

To convey these constructs within the signaling protocol, a new RSVP object and a new ERO subobject are introduced respectively.

- i) A new RSVP-TE object is introduced to convey the Exclude Route

list. This object is the Exclude Route Object (XRO).

- ii) The second type of exclusion is achieved through a modification to the existing ERO. A new subobject type the Explicit Exclude Route Subobject (EXRS) is introduced to indicate an exclusion between a pair of included abstract nodes.

SRLGs allow the definition of resources or groups of resources that share the same risk of failure. The knowledge of SRLGs may be used to compute diverse paths that can be used for protection. In systems where it is useful to signal exclusions, it may be useful to signal SRLGs to indicate groups of resources that should be excluded on the whole of a path or between two abstract nodes specified in an explicit path.

This document introduces an ERO subobject to indicate an SRLG to be signaled in either of the two exclusion methods described above. This subobject might also be appropriate for use within Explicit Routes or Record Routes, but that discussion is outside the scope of this document.

#### **4.1 Scope of Excluded Routes**

This document does not preclude a route exclusion from listing many nodes or network elements to avoid. The intent is, however, to indicate only the minimal number of subobjects to be avoided. For instance it may be necessary to signal only the SRLGs (or Shared Risk Groups) to avoid.

It is envisaged most of the conventional inclusion subobjects are specified in the signaled ERO only for the area where they pertain. The number of subobjects to be avoided, specified in the signaled XRO may be constant throughout the whole path setup, or the subobjects to be avoided may be removed from the XRO as they become irrelevant in the subsequent hops of the path setup.

For example, consider an LSP that traverses multiple computation domains. A computation domain may be an area in the administrative or IGP sense, or may be an arbitrary division of the network for active management and path computational purposes. Let the primary path be (Ingress A1,A2,AB1,B1,B2,BC1,C1,C2,Egress1) where Xn denotes a node in domain X, and XY1 denotes a node on the border of domain X and domain Y. Ingress is a node in cdomain A, and Egress is a node in domain C.

Consider the establishment of a node diverse protection path. The protection path must avoid all nodes on the primary path. The exclusions for area A are handled during CSPF at Ingress, so the ERO and XRO signaled at Ingress (A3-strict, A4-strict, AB2-strict, Egress-loose) and (B1, B2, BC1, C1, C2) respectively. At AB2 the ERO and XRO could be (B3-strict, B4-strict, BC2-strict, Egress-loose) and (C1,C2) respectively. At BC2 the ERO could be (C3-strict, C4-strict, Egress-strict) and an XRO is not needed from BC2 onwards.

In general, consideration should be given (as with explicit route) to the size of signaled data and the impact on the signaling protocol.

## **4.2 Relationship to MPLS TE MIB**

[MPLS-TE-MIB] defines managed objects for managing and modeling MPLS-based traffic engineering. Included in [\[MPLS-TE-MIB\]](#) is a means to configure explicit routes for use on specific LSPs. This configuration allows the exclusion of certain resources.

In systems where the full explicit path is not computed at the ingress (or at a path computation site for use at the ingress) it may be necessary to signal those exclusions. This document offers a means of doing this signaling.

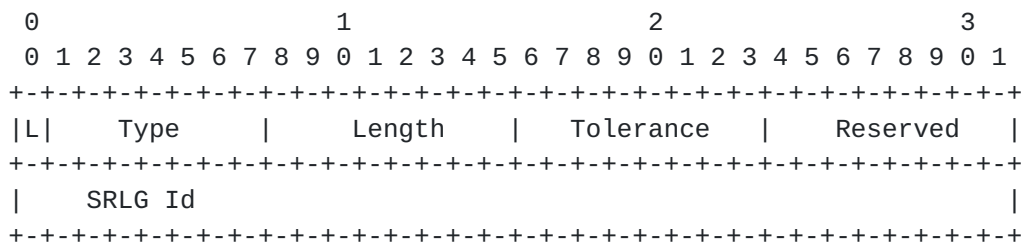
5. Shared Risk Link Groups

The identifier of a SRLG is defined as a 32 bit quantity in [GMPLS-OSPF]. These 32 bits are divided into an 8 bit type field and a 24 bit identifier in [CCAMP-SRLG].

5.1 SRLG ERO Subobject

The format of the ERO and its subobjects are defined in [RSVP-TE].

The new SRLG subobject is defined by this document as follows.



L

The L bit is an attribute of the subobject. The L bit is 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.

For exclusions, the L bit SHOULD be set to zero and ignored.

Type

The type of the subobject [TBD].

Length

The Length contains the total length of the subobject in bytes, including the Type and Length fields. The Length is always 8.

Tolerance

The level to which it is permissible for this SRLG to be included in the path when more than one SRLG is specified. A value of zero indicates that this SRLG MUST be avoided. A tolerance value of n < m indicates that the SRLG MUST be avoided in preference to an SRLG with tolerance value m.

If only one SRLG is present, then a value other than zero indicates the SRLG SHOULD be avoided.

SRLG Id

The 32 bit identifier of the SRLG.



5.2 Exclusion Tolerance Semantics

The Tolerance field in the SRLG subobject indicates the degree to which the SRLG must be avoided. (The degree to which it is permissible to include it.)

If the Tolerance field has the value zero (0), the LSP MUST NOT traverse or use any resource that is a member of the SRLG.

If the value is non-zero, all path computation elements SHOULD attempt to select routes that avoid all resources that are members of the SRLG.

Where more than one SRLG with non-zero Tolerance value is specified for exclusion and no route can be found that avoids both SRLGs, a route SHOULD be chosen that avoids the SRLG with the lower Tolerance value.

6. Exclude Route List

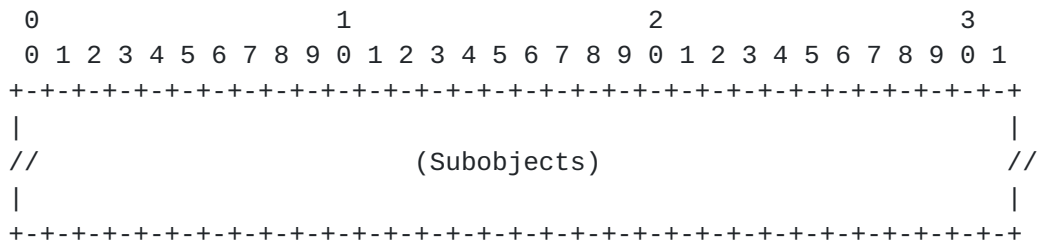
The exclude route identifies a list of abstract nodes that MUST NOT be traversed along the path of the LSP being established.

6.1 Exclude Route Object (XRO)

Abstract nodes to be excluded from the path are specified via the EXCLUDE\_ROUTE object (XRO). The Exclude Route Class value is [TBD].

Currently one C\_Type is defined, Type 1 Exclude Route. The EXCLUDE\_ROUTE object has the following format:

Class = TBD, C\_Type = 1



Subobjects

The contents of an EXCLUDE\_ROUTE object are a series of variable-length data items called subobjects. The subobjects are identical to those defined in [RSVP-TE] and [GMPLS-RSVP-TE] for use in EROs.

The following subobject types are supported.

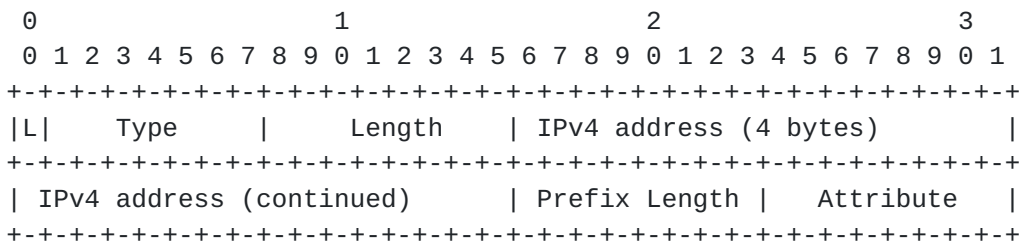
Type	Subobject
1	IPv4 prefix
2	IPv6 prefix
32	Autonomous system number
TBD	SRLG

The defined values for Type above are specified in [RSVP-TE] and in this document.

The concept of loose or strict hops has no meaning in route exclusion. The L bit, defined for ERO subobjects in [RSPV-TE], is re-used here to indicate that an abstract node MUST be avoided (value 0) or SHOULD be avoided (value 1).

An Attribute octet is introduced in the subobjects that define IP addresses to indicate the attribute (e.g. interface, node, SRLG) associated with the IP addresses that can be excluded from the path. For instance, the attribute node allows a whole node to be excluded from the path, in contrast to the attribute interface, which allows specific interfaces to be excluded from the path. The attribute SRLG allows all SRLGs associated with an IP address to be excluded from the path.

6.1.1 Subobject 1: IPv4 prefix



- L
  - 0 indicates that the attribute specified MUST be excluded
  - 1 indicates that the attribute specified SHOULD be avoided

- Attribute
  - interface
    - 0 indicates that the interface or set of interfaces associated with the IP address that should be excluded or avoided
  - node
    - 1 indicates that the node or set of nodes associated with the IP address should be excluded or avoided
  - SRLG
    - 2 indicates that all the SRLGs associated with the IP address should be excluded or avoided

Resvd  
Zero on transmission. Ignored on receipt.

The rest of the fields are as defined in [RSVP-TE].

6.1.2 Subobject 2: IPv6 Prefix

```

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   | IPv6 address (16 bytes)   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| IPv6 address (continued)                                     |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| IPv6 address (continued)                                     |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| IPv6 address (continued)                                     |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| IPv6 address (continued)   | Prefix Length | Attribute   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

L

- 0 indicates that the abstract node specified MUST be excluded
- 1 indicates that the abstract node specified SHOULD be avoided

Attribute

interface

- 0 indicates that the interface or set of interfaces associated with the IP address that should be excluded or avoided

node

- 1 indicates that the node or set of nodes associated with the IP address should be excluded or avoided

SRLG

- 2 indicates that all the SRLG associated with the IP address should be excluded or avoided

Resvd

Zero on transmission. Ignored on receipt.

The rest of the fields are as defined in [[RSVP-TE](#)].

### **6.1.3 Subobject 32: Autonomous System Number**

The L bit of an Autonomous System Number subobject does has meaning in an Exclude Route (contrary to its usage in an Explicit Route defined in [[RSVP-TE](#)]). The meaning is as for other subobjects described above. That is:

- 0 indicates that the abstract node specified MUST be excluded
- 1 indicates that the abstract node specified SHOULD be avoided

The rest of the fields are as defined in [[RSVP-TE](#)]. There is no Attribute octet defined.

### **6.1.4 Subobject TBD: SRLG**

The Attribute octet is not present. The rest of the fields are as defined in the "SRLG ERO Subobject" section of this document.

## **6.2. Semantics and Processing Rules for the Exclude Route Object (XRO)**

The exclude route list is encoded as a series of subobjects contained in an EXCLUDE\_ROUTE object. Each subobject identifies an abstract node in the exclude route list.

Each abstract node may be a precisely specified IP address a node, or an IP address with prefix identifying interfaces of a group of nodes, or an Autonomous System.

The Explicit Route and routing processing is unchanged from the description in [[RSVP-TE](#)] with the following additions:

- a. When a Path message is received at a node, the node must check that it is not a member of any of the abstract nodes in the XRO if it is present in the Path message. If the node is a member of any of the abstract nodes in the XRO it should return a PathErr with the error code "Routing Problem" and error value of "Local node in Exclude Route". If there are SRLGs in the XRO, the node should check that it and the resources it uses are not part of any SRLG that is specified with Tolerance value of zero. If it is, it

should return a PathErr with the error code "Routing Problem" and error value of "Local node in Exclude Route". The node may be a member of an SRLG in the XRO that is specified with a non-zero Tolerance value.

- b. When choosing a next hop or expanding an explicit route to include additional subobjects, a node:
  - i) must not introduce an explicit node or an abstract node that equals or is a member of any abstract node that is specified in the Exclude Route Object.
  - ii) must not (or should not, in the case of a non-zero Tolerance value) introduce links, nodes or resources identified by the SRLG ID specified in the SRLG subobjects(s). If these rules preclude further forwarding of the Path message, the node should return a PathErr with the error code "Routing Problem" and error value of "Route blocked by Exclude Route".
- c. The subobjects in the ERO and XRO SHOULD not contradict each other. If they do contradict, the subobjects with the L bit not set, strict or MUST be excluded, respectively, in the ERO or XRO MUST take precedence. If there is still a conflict, the subobjects in the ERO MUST take precedence.

The XRO Class-Num is of the form 11bbbbbb so that nodes which do not support the XRO will forward it uninspected and will not apply the extensions to ERO processing described above. This makes the XRO a 'best effort' process.

This 'best-effort' approach is chosen to allow route exclusion to traverse parts of the network that are not capable of parsing or handling the new function. Note that Record Route may be used to allow computing nodes to observe violations of route exclusion and attempt to re-route the LSP accordingly.

## **7. Explicit Exclude Route**

The Explicit Exclude Route defines abstract nodes or resources (such as links, unnumbered interfaces or labels) that must not be used on the path between two inclusive abstract nodes or resources in the explicit route.

### **7.1. Explicit Exclusion Route Subobject (EXRS)**

A new ERO subobject type is defined. The Explicit Exclude Route Subobject (EXRS) has type [TBD]. The EXRS may not be present in an RRO or XRO.

The format of the EXRS is as follows.

```

0                               1
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
|L|   Type   |   Length   |   EXRS subobjects   |
+-----+-----+-----+-----+-----+-----+-----+

```



L

ignored and must be zero

[Note: The L bit in an ERES subobject is as defined for the XRO subobjects]

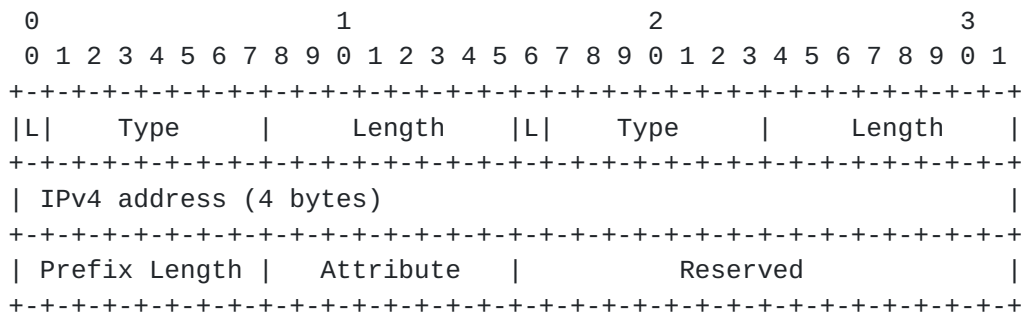
Type

The type of the subobject, i.e. EXRS [TBD]

EXRS subobjects

An EXRS subobject indicates the abstract node or resource to be excluded. The format of this field is exactly the format of an XRO subobject and may include an SRLG subobject. Both subobjects are as described earlier in this document.

Thus, an EXRO subobject for an IP hop might look as follows:



Note: The Most Significant Bit in the Type field could be used to indicate exclusion of IPv4/IPv6, AS and SRLG subobjects, eliminating the need to prepend the subobject with an additional TLV header. This would reduce the number bytes require for each subobject by 2 bytes. However, this approach would reduce the ERO Type field space by half. This issue need WG discussion and feedback.

### 7.2. Semantics and Processing Rules for the EXRS

Each EXRS may carry multiple exclusions. The exclusion is encoded exactly as for XRO subobjects and prefixed by an additional Type and Length.

The scope of the exclusion is the step between the previous ERO subobject that identifies an abstract node, and the subsequent ERO subobject that identifies an abstract node. Multiple exclusions may be present between any pair of abstract nodes.

Exclusions may indicate explicit nodes, abstract nodes or Autonomous Systems that must not be traversed on the path to the next abstract node indicated in the ERO.

Exclusions may also indicate resources (such as unnumbered interfaces, link ids, labels) that must not be used on the path to

the next abstract node indicated in the ERO.

SRLGs may also be indicated for exclusion from the path to the next abstract node in the ERO by the inclusion of an EXRO Subobject containing an SRLG subobject. If the Tolerance value in the SRLG subobject is zero, the resources (nodes, links, etc.) identified by the SRLG must not be used on the path to the next abstract node indicated in the ERO. If the Tolerance value is non-zero, the resources identified by the SRLG should be avoided, but may be used in preference to resources associated with another SRLG indicated for exclusion if that SRLG has a (numerically) lower Tolerance value.

The subobjects in the ERO and EXRS SHOULD not contradict each other. If they do contradict, the subobjects with the L bit not set, strict or MUST be excluded, respectively, in the ERO or XRO MUST take precedence. If there is still a conflict, the subobjects in the ERO MUST take precedence.

If a node is called upon to process an EXRS and does not support handling of exclusions it will return a PathErr with a "Bad EXPLICIT\_ROUTE object" error.

If the presence of EXRO Subobjects precludes further forwarding of the Path message, the node should return a PathErr with the error code "Routing Problem" and error value of "Route blocked by Exclude Route".

## **8. Security**

The new exclude route object poses no security exposures over and above [[RSVP-TE](#)] and [[GMPLS-RSVP-TE](#)]. Note that any security concerns that exist with Explicit Routes should be considered with regard to route exclusions.

## **9. IANA Considerations**

### **9.1. New Class Numbers**

One new class number is required.

```
EXCLUDE_ROUTE
  Class-Num = 011bbbbbb
  CType: 1
```

### **9.2. New Subobject Types**

A new subobject type for the Exclude Route Object and Explicit Exclude Route Subobject is required.

SRLG subobject

A new subobject type for the ERO is required.

Explicit Exclude Route subobject

### **9.3. New Error Codes**

New error values are needed for the error code 'Routing Problem'.

```
Unsupported Exclude Route Subobject Type [TBD]
Local Node in Exclude Route [TBD]
Route Blocked by Exclude Route [TBD]
```



## **10. Acknowledgments**

This document reuses text from [[RSVP-TE](#)] for the description of EXCLUDE\_ROUTE.

The authors would like to express their thanks to Igor Bryskin, Lou Berger and Dimitri Papadimitriou for their considered opinions on this draft. Also thanks to Yakov Rekhter for reminding us about SRLGs!

## **11. Normative References**

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997
- [RSVP-TE] D. Awduche, et al., "RSVP-TE: Extensions to RSVP for LSP Tunnels", [RFC 3209](#), December 2001.
- [GMPLS-RSVP-TE] L. Berger (Ed.), "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Extensions", [RFC 3473](#), January 2003.
- [GMPLS-OSPF] K. Kompela, et al., "OSPF Extensions in Support of Generalized MPLS", Internet Draft, [draft-ietf-ccamp-ospf-gmpls-extensions-09.txt](#), December 2002 (work in progress).
- [CCAMP-SRLG] D. Papadimitriou, et al., "Shared Risk Link Groups Encoding and Processing", Internet Draft, [draft-papadimitriou-ccamp-srlg-processing-01.txt](#), November 2002 (work in progress).
- [MPLS-TE-MIB] C. Srinivasan, et al., "Multiprotocol Label Switching (MPLS) Traffic Engineering Management Information Base", Internet Draft, [draft-ietf-mpls-te-mib-09.txt](#), November 2002 (work in progress).

## **12. Informational References**

- [MPLS-BUNDLE] Kompella, K., Rekhter, Y., and Berger, L., "Link Bundling in MPLS Traffic Engineering", Internet Draft, [draft-ietf-mpls-bundle-04.txt](#), July 2002, (work in progress).
- [MPLS-UNNUM] Kompella, K., Rekhter, Y., "Signalling Unnumbered Links in RSVP-TE", [RFC 3477](#), January 2003.



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