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**Encoding of Attributes for Multiprotocol Label Switching (MPLS)
Label Switched Path (LSP) Establishment Using RSVP-TE**

[draft-ietf-mpls-rsvpte-attributes-02.txt](#)

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Abstract

Multiprotocol Label Switching (MPLS) Label Switched Paths (LSPs) may be established using the Resource Reservation Protocol Traffic Engineering extensions (RSVP-TE). This protocol includes an object (the SESSION_ATTRIBUTE object) which carries a flags field used to indicate options and attributes of the LSP. That flags field has eight bits allowing for eight options to be set. Recent proposals in many documents that extend RSVP-TE have suggested uses for each of the previously unused bits.

This document defines a new object for RSVP-TE messages that allows the signaling of further attribute bits and also the carriage of

arbitrary attribute parameters to make RSVP-TE easily extensible to support new requirements. Additionally, this document defines a way to record the attributes applied to the LSP on a hop-by-hop basis.

The object mechanisms defined in this document are equally applicable to Generalized MPLS (GMPLS) Packet Switch Capable (PSC) LSPs and to GMPLS non-PSC LSPs.

0. Change History

This section to be removed before publication.

0.1 Changes from 01 to 02 Version

- Minor typographical changes.

0.2 Changes from 00 to 01 Version

- Change Attributes Flags TLV to be variable length so that more bits can easily be added in the future.
- Define default behaviors for bits absent from the TLV and for absence of the TLV.
- Clarify the IANA requirements for tracking Attributes Flags bits.
- Introduce RRO Attributes Subobject and describe usage.
- Move Fast Reroute reference to informational.
- Update security considerations to handle new RRO subobject
- Remove section that explained the need for this document in advance of any definitive bit definitions.
- Tighten rules for processing LSP_ATTRIBUTES object in cases where TLVs are unknown or unsupported.
- Clarify that LSP Attributes apply to individual LSPs and not to entire sessions.

1. Introduction and Problem Statement

Traffic Engineered Multiprotocol Label Switching (MPLS) Label Switched Paths (LSPs) [[RFC3031](#)] may be set up using the Path message of the RSVP-TE signaling protocol [[RFC3209](#)]. The Path message includes the SESSION_ATTRIBUTE object which carries a flags field used to indicate desired options and attributes of the LSP.

The flags field in the SESSION_ATTRIBUTE object has eight bits. Just three of those bits are assigned in [[RFC3209](#)]. A further two bits are assigned in [[FRR](#)] for fast re-reroute functionality leaving only three bits available. Several recent proposals and Internet Drafts have demonstrated that there is a high demand for the use of the other three bits. Some, if not all, of those proposals are likely to go forward as RFCs resulting in depletion or near depletion of the

flags field and a consequent difficulty in signaling new options and attributes that may be developed in the future.

This document defines a new object for RSVP-TE messages that allows the signaling of further attributes bits. The new object is constructed from TLVs, and a new TLV is defined to carry a variable number of attributes bits. Because of the nature of the TLV construction the object is flexible and allows the future definition of:

- further bit flags if further, distinct uses are discovered
- arbitrary options and attributes parameters carried as individual TLVs.

Note that the LSP Attributes defined in this document are specifically scoped to an LSP. They may be set differently on separate LSPs with the same Tunnel ID between the same source and destination (that is, within the same Session).

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It is noted that that some options and attributes do not need to be acted on by all Label Switched Routers (LSRs) along the path of the LSP. In particular, these options and attributes may apply only to key LSRs on the path such as the ingress and egress. Special transit LSRs, such as area or AS Border Routers (ABR/ASBRs) may also fall into this category. This means that the new options and attributes should be signaled transparently, and only examined at those points that need to act on them.

On the other hand, other options and attributes may require action at all transit LSRs along the path of the LSP. Inability to support the required attributes by one of those transit LSRs may require the LSR to refuse the establishment of the LSP.

These considerations are particularly important in the context of backwards compatibility. In general, it should be possible to provide new MPLS services across a legacy network without upgrading those LSRs that do not need to participate actively in the new services.

Note that options already specified for the SESSION_ATTRIBUTE object in pre-existing RFCs are not migrated to the new mechanisms described in this document.

RSVP includes a way for unrecognized objects to be transparently forwarded by transit nodes without them refusing the incoming protocol messages and with the objects being stripped from the outgoing protocol message (see [\[RFC2205\] section 3.10](#)). This capability extends to RSVP-TE and provides a good way to ensure that only those LSRs that understand a particular object examine it.

This document distinguishes between options and attributes that are only required at key LSRs along the path of the LSP, and those that must be acted on by every LSR along the LSP. Two LSP Attributes objects are defined in this document: the first may be passed transparently by LSRs that do not recognize it, the second must cause LSP setup failure with the generation of a PathErr message with an appropriate Error Code if an LSR does not recognize it.

1.1 Applicability to Generalized MPLS

The RSVP-TE signaling protocol also forms the basis of a signaling protocol for Generalized MPLS (GMPLS) as described in [[RFC3471](#)] and [[RFC3473](#)]. The extensions described in this document are intended to be equally applicable to MPLS and GMPLS.

1.2 A Rejected Alternate Solution

A rejected alternate solution was to define a new C-Type for the existing SESSION_ATTRIBUTE object. This new C-Type could allow a larger Flags field and address the immediate problem.

This solution was rejected because:

- A new C-Type is not backward compatible with deployed implementations that expect to see a C-Type of 1 or 7. It is important that any solution be capable of carrying new attributes transparently across legacy LSRs if those LSRs are not required to act on the attributes.

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- Support for arbitrary attributes parameters through TLVs would have meant a significant change of substance to the existing object.

2. Terminology

This document uses terminology from the MPLS architecture document [[RFC3031](#)] and from the RSVP-TE protocol specification [[RFC3209](#)] which inherits from the RSVP specification [[RFC2205](#)].

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](#) [6].

3. Attributes TLVs

Attributes carried by the new objects defined in this document are encoded within TLVs. One or more TLVs may be present in each object. There are no ordering rules for TLVs and no interpretation should be placed on the order in which TLVs are received.

[illegible]

The identifier of the TLV.

The length of the value field in bytes. Thus if no value field is present the length field contains the value zero. Each value field must be zero padded at the end to take it up to a four byte boundary - the padding is not included in the length so that a one byte value would be encoded in an eight byte TLV with length field set to one.

The data for the TLV padded as described above.

This document defines only one TLV type value. Type 1 indicates the Attributes Flags TLV. Other TLV types may be defined in future with type values assigned by IANA.

The Attributes Flags TLV value field is a variable length array of flags numbered from the MSB as bit zero. The length field for this

TLV is always a multiple of 4 bytes, regardless of the number bits carried.

Unassigned bits are considered as reserved and MUST be set to zero on transmission by the originator of the object. Bits not contained in the TLV MUST be assumed to be set to zero. If the TLV is absent either because it is not contained in the LSP_ATTRIBUTES or LSP_REQUIRED_ATTRIBUTES object, or because those objects are themselves absent, all processing MUST be performed as though the bits were present and set to zero.

No bits are defined in this document. The assignment of bits is managed by IANA.

4. LSP_ATTRIBUTES Object

The LSP_ATTRIBUTES object is used to signal attributes required in support of an LSP, or to indicate the nature or use of an LSP where that information is not required to be acted on by all transit LSRs. Specifically, if an LSR does not support the object, it forwards it unexamined and unchanged. This facilitates the exchange of attributes across legacy networks that do not support this new object.

This object effectively extends the flags field in the SESSION_ATTRIBUTE object and allows for the future inclusion of more complex objects through TLVs.

Note that some function may require an LSR to inspect both the SESSION_ATTRIBUTE object, and the LSP_ATTRIBUTES or LSP_REQUIRED_ATTRIBUTES object.

The LSP_ATTRIBUTES object class is TBD of the form 11bbbbbb. This C-Num value (see [section 7](#)) ensures that LSRs that do not recognize the object pass it on transparently.

One C-Type is defined, C-Type = 1 for LSP Attributes.

This object is optional and may be placed on Path messages to convey additional information about the desired attributes of the LSP.

4.1 Format

LSP_ATTRIBUTES class = TBD, C-Type = 1

```

      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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                                                                    |
//                               Attributes TLVs                               //
|                                                                    |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
```

The Attributes TLVs are encoded as described in [section 3](#).

4.2 Generic Processing Rules

An LSR that does not support this object will pass it on unaltered because of the C-Num.

An LSR that does support this object, but does not recognize a TLV type code carried in this object **MUST** pass the TLV on unaltered in the LSP_ATTRIBUTES object that it places in the Path message that it sends downstream.

An LSR that does support this object and recognizes a TLV but does not support the attribute defined by the TLV **MUST** act as specified in the document that defines the TLV.

An LSR that supports the Attributes Flags TLV, but does not recognize a bit set in the Attributes Flags TLV **MUST** forward the TLV unchanged.

An LSR that supports the Attributes Flags TLV and recognizes a bit that is set but does not support the indicated attribute **MUST** act as specified in the document that defines the bit.

5. LSP_REQUIRED_ATTRIBUTES Object

The LSP_REQUIRED_ATTRIBUTES object is used to signal attributes required in support of an LSP, or to indicate the nature or use of an LSP where that information **MUST** be inspected at each transit LSR. Specifically, each transit LSR **MUST** examine the attributes in the LSP_REQUIRED_ATTRIBUTES object and **MUST NOT** forward the object transparently.

This object effectively extends the flags field in the SESSION_ATTRIBUTE object and allows for the future inclusion of more complex objects through TLVs. It complements the LSP_ATTRIBUTES object.

The LSP_REQUIRED_ATTRIBUTES object class is TBD of the form 0bbbbbbb. This C-Num value ensures that LSRs that do not recognize the object reject the LSP setup effectively saying that

they do not support the attributes requested. This means that this object SHOULD only be used for attributes that require support at some transit LSRs and so require examination at all transit LSRs. See [section 4](#) for how end-to-end and selective attributes are signaled.

One C-Type is defined, C-Type = 1 for LSP Required Attributes.

This object is optional and may be placed on Path messages to convey additional information about the desired attributes of the LSP.

5.1 Format

LSP_REQUIRED_ATTRIBUTES class = TBD, C-Type = 1

```

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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|
//               Attributes TLVs               //
|
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

The Attributes TLVs are encoded as described in [section 3](#).

5.2 Generic Processing Rules

An LSR that does not support this object will use a PathErr to reject the Path message based on the C-Num using the error code "Unknown Object Class".

An LSR that does not recognize a TLV type code carried in this object MUST reject the Path message using a PathErr with Error Code "Unknown Attributes TLV" and Error Value set to the value of the unknown TLV type code.

An LSR that does not recognize a bit set in the Attributes Flags TLV MUST reject the Path message using a PathErr with Error Code "Unknown Attributes Bit" and Error Value set to the bit number of the unknown bit in the Attributes Flags.

An LSR that recognizes an attribute, however encoded, but which does not support that attribute MUST act according to the behavior specified in the document that defines that specific attribute.

6. Recording Attributes

6.1 Requirements

Additionally, there may be other qualities that need to be reported on a hop-by-hop basis. These are currently indicated in the Flags field of RRO subobjects. Since there are only eight bits available in this field, and since some are already assigned and there is also likely to be an increase in allocations in new documents, there is a need for some other method to report per-hop attributes.

The Length contains the total length of the subobject in bytes,

including the Type and Length fields. This length must be a multiple of 4 and must be at least 8.

Attribute Flags

The attribute flags recorded for the specific hop.

6.3 Procedures

6.3.1 Subobject Presence Rules

The Attributes subobject is pushed onto the RECORD_ROUTE object immediately prior to pushing the node's IP address or link identifier. Thus, if label recording is being used, the Attributes subobject SHOULD be pushed onto the RECORD_ROUTE object after the Record Label subobject(s).

A node MUST NOT push an Attributes subobject on to the RECORD_ROUTE object without also pushing an IPv4, IPv6 or Unnumbered Interface ID subobject.

This means that an Attributes subobject is bound to the LSR identified by the subobject found in the RRO immediately before the Attributes subobject.

If the new subobject causes the RRO to be too big to fit in a Path (or Resv) message, the processing MUST be as described in [[RFC3209](#)].

If more than one Attributes subobject is found between a pair of subobjects that identify LSRs, only the first one found (that is, the nearest to the stop of the stack) SHALL have any meaning within the context of this document. All such subobjects MUST be forwarded unmodified by transit LSRs.

6.3.2 Reporting Compliance with LSP Attributes

To report compliance with an attribute requested in the Attributes Flags TLV, an LSR MAY set the corresponding bit (see [section 7](#)) in the Attributes subobject. To report non-compliance, an LSR MAY clear the corresponding bit in the Attributes subobject.

The requirement to report compliance MUST be specified in the document that defines the usage of any bit. This will reduce to a statement of whether hop-by-hop acknowledgement is required.

6.3.3 Reporting Per-Hop Attributes

To report a per-hop attribute, an LSR sets the appropriate bit in the Attributes subobject.

The requirement to report a per-hop attribute **MUST** be specified in the document that defines the usage of the bit.

6.3.4 Default Behavior

By default all bits in an Attributes subobject **SHOULD** be set to zero.

If a received Attribute subobject is not long enough to include a specific numbered bit, that bit **MUST** be treated as though present and as if set to zero.

If the RRO subobject is not present for a hop in the LSP, all bits **MUST** be assumed to be set to zero.

7. Summary of Attribute Bit Allocation

This document defines two uses of per-LSP attribute flag bit fields. The bit numbering in the Attributes Flags TLV and the RRO Attributes subobject is identical. That is, the same attribute is indicated by the same bit in both places. This means that only a single registry of bits is maintained.

The consequence is a degree of clarity in implementation and registration.

Note, however, that it is not always the case that a bit will be used in both the Attributes Flags TLV and the RRO Attributes subobject. For example, an attribute may be requested using the Attributes Flags TLV, but there is no requirement to report the handling of the attribute on a hop-by-hop basis. Conversely, there may be a requirement to report the attributes of an LSP on a hop-by-hop basis, but there is no corresponding request attribute.

In these cases, a single bit number is still assigned for both the Attributes Flags TLV and the RRO Attributes subobject even though the bit may be irrelevant in either the Attributes Flags or the RRO Attributes subobject. The document that defines the usage of the new bit **MUST** state in which places it is used and **MUST** handle a default setting of zero.

8. Message Formats

The LSP_ATTRIBUTES object and the LSP_REQUIRED_ATTRIBUTES object **MAY** be carried in a Path message.

The order of objects in RSVP-TE messages is recommended, but implementations must be capable of receiving the objects in any meaningful order. The LSP_ATTRIBUTES object and LSP_REQUIRED_ATTRIBUTES objects are RECOMMENDED to be placed immediately after the SESSION_ATTRIBUTE object if it is present, or otherwise immediately after the LABEL_REQUEST object.

If both the LSP_ATTRIBUTES object and the LSP_REQUIRED_ATTRIBUTES object are present, the LSP_REQUIRED_ATTRIBUTES object is RECOMMENDED to be placed first.

LSRs SHOULD be prepared to receive these objects in any order in any position within a Path message. Subsequent instances of these objects within a Path message SHOULD be ignored and those objects MUST be forwarded unchanged transparently.

9. IANA Considerations

9.1 New RSVP C-Nums and C-Types

Two new RSVP C-Nums are defined in this document and should be assigned by IANA.

o LSP_ATTRIBUTES object

The C-Num should be of the form 11bbbbbb so that LSRs that do not recognize the object will ignore the object but forward it, unexamined and unmodified, in all messages resulting from this message.

One C-Type is defined for this object and should be assigned by IANA.

o LSP Attributes TLVs

Recommended C-Type value 1.

o LSP_REQUIRED_ATTRIBUTES object

The C-Num should be of the form 0bbbbbbb so that LSRs that do not recognize the object will reject the message that carries it with an "Unknown Object Class" error.

One C-Type is defined for this object and should be assigned by IANA.

- o LSP Required Attributes TLVs

Recommended C-Type value 1.

9.2 New TLV Space

The two new objects referenced above are constructed from TLVs. Each TLV includes a 16-bit type identifier (the T-field). The same T-field values are applicable to both objects.

IANA is requested to manage TLV type identifiers as follows:

- TLV Type (T-field value)
- TLV Name
- Whether allowed on LSP_ATTRIBUTES object
- Whether allowed on LSP_REQUIRED_ATTRIBUTES object.

This document defines one TLV type as follows:

- TLV Type = 1
- TLV Name = Attributes Flags TLV
- allowed on LSP_ATTRIBUTES object
- allowed on LSP_REQUIRED_ATTRIBUTES object.

9.3 Attributes Flags

This document provides new attributes bit flags for use in other documents that specify new RSVP-TE attributes. These flags are present in the Attributes Flags TLV referenced in the previous section.

IANA is requested to manage the space of attributes bit flags numbering them in the usual IETF notation starting at zero and continuing through 2039.

Each bit should be tracked with the following qualities:

- Bit number
- Defining RFC
- Name of bit
- Whether there is meaning in the Attribute Flags TLV (yes/no)
- Whether there is meaning in the RRO Attributes Subobject (yes/no).

Note that this means that all bits in the Attribute Flags TLV and the RRO Attributes Subobject use the same bit number regardless of whether they are used in one or both places. Thus, only one list of bits is required to be maintained. (It would be meaningless in the context of this document for a bit to have no meaning in neither the Attribute Flags TLV nor the RRO Attributes Subobject.)

9.4 SESSION_ATTRIBUTE Flags Field

This document does not make any alterations to the definition of the

existing SESSION_ATTRIBUTE object nor to the definition of meanings assigned to the flags in the Flags field of that object. These flags are assigned meanings in various other RFCs and Internet Drafts.

It is suggested that IANA manage the allocation of meaning to the bits in the Flags field of the SESSION_ATTRIBUTE object to prevent accidental double allocation of any one bit.

9.5 New Error Codes

This document defines the following new error codes and error values. Numeric values should be assigned by IANA.

Error Code	Error Value
"Unknown Attributes TLV"	Identifies the unknown TLV type code.
"Unknown Attributes Bit"	Identifies the unknown Attribute Bit.

9.6 New Record Route Subobject Identifier

A new subobject is defined for inclusion in the RECORD_ROUTE object.

The RRO Attributes subobject is identified by a Type value of TBD.

10. Security Considerations

This document adds two new objects to the RSVP Path message as used in MPLS and GMPLS signaling, and a new subobject to the RECORD_ROUTE object carried on may RSVP messages. It does not introduce any new direct security issues and the reader is referred to the security considerations expressed in [[RFC2205](#)], [[RFC3209](#)] and [[RFC3473](#)].

It is of passing note that any signaling request that indicates the functional preferences or attributes of an MPLS LSP may provide anyone with unauthorized access to the contents of the message with information about the LSP that an administrator may wish to keep secret. Although this document adds new objects for signaling desired LSP attributes, it does not contribute to this issue which can only be satisfactorily handled by encrypting the content of the signaling message.

Similarly, the addition of attribute recording information to the RRO may reveal information about the status of the LSP and the capabilities of individual LSRs that operators wish to keep secret. The same strategy that applies to other RRO subobjects also applies here. Note, however, that there is a tension between notifying the head end of the LSP status at transit LSRs, and hiding the existence or identity of the transit LSRs.

11. Acknowledgements

Credit to the OSPF Working Group for inspiration from their solution to a similar problem.

Thanks to Rahul Aggarwal for his careful review and support of this work. Thanks also to Raymond Zhang, Kireeti Kompella, Philip Matthews and Jim Gibson for their input.

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13. Normative References

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14. Informative References

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