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Generalized MPLS Signaling - CR-LDP Extensions

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Abstract

This document describes extensions to CR-LDP signaling required to support Generalized MPLS. Generalized MPLS extends MPLS to encompass

time-division (e.g. SONET ADMs), wavelength (optical lambdas) and spatial switching (e.g. incoming port or fiber to outgoing port or fiber). This document presents a CR-LDP specific description of the extensions. An RSVP-TE specific description can be found in [GMPLS-RSVP]. A generic functional description is presented in [GMPLS-SIG].

Contents

Changes from previous version:

o Fixed Label Set format

1. Introduction

Generalized MPLS extends MPLS from supporting packet (PSC) interfaces and switching to include support of three new classes of interfaces and switching: Time-Division Multiplex (TDM), Lambda Switch (LSC) and Fiber-Switch (FSC). A functional description of the extensions to MPLS signaling needed to support the new classes of interfaces and switching is provided in [GMPLS-SIG]. This document presents CR-LDP specific formats and mechanisms needed to support all four classes of interfaces. RSVP-TE extensions can be found in [GMPLS-RSVP].

[GMPLS-SIG] should be viewed as a companion document to this document. The format of this document parallels [GMPLS-SIG]. It should be noted that the RSVP-TE specific version of Generalized MPLS includes RSVP specific support for rapid failure notification, see Section 4 [GMPLS-RSVP]. For CR-LDP there is not currently a similar mechanism. When a failure is detected it will be propagated with RELEASE/WITHDRAW messages radially outward from the point of failure. Resources are to be released in this phase and actual resource information may be fed back to the source using a feedback mechanisms.

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. Label Related Formats

This section defines formats for a generalized label request, a generalized label, support for waveband switching, suggested label and label sets.

2.1. Generalized Label Request

A REQUEST message SHOULD contain as specific an LSP Encoding Type as possible to allow the maximum flexibility in switching by transit LSRs. A Generalized Label Request TLV is set by the ingress node, transparently passed by transit nodes, and used by the egress node.

The format of a Generalized Label Request is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|          0x0901           |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| LSP Enc. Type |    Reserved   |             G-PID             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

See [GMPLS-SIG] for a description of parameters.

2.1.1. Procedures

A node processing a REQUEST message containing a Generalized Label Request must verify that the requested parameters can be satisfied by the incoming interface, the node and by the outgoing interface. The node may either directly support the LSP or it may use a tunnel (FA), i.e., another class of switching. In either case, each parameter must be checked.

Note that local node policy dictates when tunnels may be used and when they may be created. Local policy may allow for tunnels to be dynamically established or may be solely administratively controlled. For more information on tunnels and processing of ER hops when using tunnels see [MPLS-HIERARCHY].

Transit and egress nodes MUST verify that the node itself and, where appropriate, that the outgoing interface or tunnel can support the requested LSP Encoding Type. If encoding cannot be supported, the node MUST generate a NOTIFICATION message, with a "Routing problem/Unsupported Encoding" indication.

The G-PID parameter is normally only examined at the egress. If the indicated G-PID cannot be supported then the egress MUST generate a NOTIFICATION message, with a "Routing problem/Unsupported GPID" indication. In the case of PSC and when penultimate hop popping (PHP) is requested, the penultimate hop also examines the (stored) G-PID during the processing of the MAPPING message. In this case if the G-PID is not supported, then the penultimate hop MUST generate a NOTIFICATION message with a "Routing problem/Unacceptable label value" indication. The generated NOTIFICATION message MAY include an Acceptable Label Set, see Section 4.

When an error message is not generated, normal processing occurs. In the transit case this will typically result in a REQUEST message being propagated. In the egress case and PHP special case this will

typically result in a MAPPING message being generated.

2.1.2. Bandwidth Encoding

Bandwidth encodings are carried in the CR-LDP Traffic Parameters TLV. See [GMPLS-SIG] for a definition of values to be used for specific signal types. These values are set in the Peak and Committed Data Rate fields of the Traffic Parameters TLV. Other bandwidth/service related parameters in the TLV are ignored and carried transparently.

2.2. Generalized Label

The format of a Generalized Label is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|          0x0902           |      Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             Label                             |
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

See [GMPLS-SIG] for a description of parameters and encoding of labels.

2.2.1. Procedures

The Generalized Label travels in the upstream direction in MAPPING messages.

The presence of both a generalized and normal label TLV in a MAPPING message is a protocol error and should treated as a malformed message by the recipient.

The recipient of a MAPPING message containing a Generalized Label verifies that the values passed are acceptable. If the label is unacceptable then the recipient MUST generate a NOTIFICATION message with a "Routing problem/MPLS label allocation failure" indication. The generated NOTIFICATION message MAY include an Acceptable Label Set, see Section 4.

2.3. Waveband Switching

Waveband switching uses the same format as the generalized label, see section 2.2. The type (0x0903) is assigned for the Waveband Label.

In the context of waveband switching, the generalized label has the following format:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|          0x0903           |      Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Waveband Id                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Start Label                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            End Label                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

See [GMPLS-SIG] for a description of parameters.

2.3.1. Procedures

The procedures defined in Section 2.2.1 apply to waveband switching. This includes generating a NOTIFICATION message with a "Routing problem/MPLS label allocation failure" indication if any of the label fields are unrecognized or unacceptable.

Additionally, when a waveband is switched to another waveband, it is possible that the wavelengths within the waveband will be mirrored about a center frequency. When this type of switching is employed, the start and end label in the waveband label TLV MUST be flipped before forwarding the label TLV with the new waveband Id. In this manner an egress/ingress LSR which receives a waveband label which has these values inverted, knows that it must also invert its egress association to pick up the proper wavelengths. Without this mechanism and with an odd number of mirrored switching operations, the egress LSRs will not know that an input wavelength of say L1 will emerge from the waveband tunnel as L100.

This operation MUST be performed in both directions when a bidirectional waveband tunnel is being established.

2.4. Suggested Label

The format of a suggested label is identical to a generalized label. It is used in REQUEST messages. Suggested Label uses type = 0x904.

Errors in received Suggested Labels MUST be ignored. This includes any received inconsistent or unacceptable values.

2.5. Label Set

The format of a Label_Set is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|  type=0x0905              |      Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Action     |      Reserved     |        Label Type         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Subchannel 1                         |
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                                :                              :
:                                :                              :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Subchannel N                         |
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Label Type: 14 bits

Indicates the type and format of the labels carried in the TLV. Values match the TLV type of the appropriate Label TLV.

See [GMPLS-SIG] for a description of other parameters.

2.5.1. Procedures

A Label Set is defined via one or more Label_Set TLVs. Specific labels/subchannels can be added to or excluded from a Label Set via Action zero (0) and one (1) TLVs respectively. Ranges of labels/subchannels can be added to or excluded from a Label Set via Action two (2) and three (3) TLVs respectively. When the Label_Set TLVs only list labels/subchannels to exclude, this implies that all other labels are acceptable.

The absence of any Label_Set TLVs implies that all labels are acceptable. A Label Set is included when a node wishes to restrict the label(s) that may be used downstream.

On reception of a REQUEST message, the receiving node will restrict its choice of labels to one which is in the Label Set. Nodes capable of performing label conversion may also remove the Label Set prior to forwarding the REQUEST message. If the node is unable to pick a label from the Label Set or if there is a problem parsing the Label_Set TLVs, then the request is terminated and a NOTIFICATION message with a "Routing problem/Label Set" indication MUST be generated. It is a local matter if the Label Set is stored for later selection on the MAPPING or if the selection is made immediately for propagation in the MAPPING.

On reception of a REQUEST message, the Label Set represented in the message is compared against the set of available labels at the downstream interface and the resulting intersecting Label Set is forwarded in a REQUEST message. When the resulting Label Set is empty, the REQUEST must be terminated, and a NOTIFICATION message, and a "Routing problem/Label Set" indication MUST be generated. Note that intersection is based on the physical labels (actual wavelength/band values) which may have different logical values on different links, as a result it is the responsibility of the node to map these values so that they have a consistent physical meaning, or to drop the particular values from the set if no suitable logical label value exists.

When processing a MAPPING message at an intermediate node, the label propagated upstream MUST fall within the Label Set.

Note, on reception of a MAPPING message a node that is incapable of performing label conversion has no other choice than to use the same physical label (wavelength/band) as received in the MAPPING message. In this case, the use and propagation of a Label Set will significantly reduce the chances that this allocation will fail.

3. Bidirectional LSPs

Bidirectional LSP setup is indicated by the presence of an Upstream Label in the REQUEST message. An Upstream Label has the same format as the generalized label, see Section 2.2. Upstream Label uses type=0x0906

3.1. Procedures

The process of establishing a bidirectional LSP follows the establishment of a unidirectional LSP with some additions. To support bidirectional LSPs an Upstream Label is added to the REQUEST message. The Upstream Label MUST indicate a label that is valid for forwarding at the time the REQUEST message is sent.

When a REQUEST message containing an Upstream Label is received, the receiver first verifies that the upstream label is acceptable. If the label is not acceptable, the receiver MUST issue a NOTIFICATION message with a "Routing problem/Unacceptable label value" indication. The generated NOTIFICATION message MAY include an Acceptable Label Set, see Section 4.

An intermediate node must also allocate a label on the outgoing interface and establish internal data paths before filling in an outgoing Upstream Label and propagating the REQUEST message. If an intermediate node is unable to allocate a label or internal resources, then it MUST issue a NOTIFICATION message with a "Routing problem/Label allocation failure" indication.

Terminator nodes process REQUEST messages as usual, with the exception that the upstream label can immediately be used to transport data traffic associated with the LSP upstream towards the initiator.

When a bidirectional LSP is removed, both upstream and downstream labels are invalidated and it is no longer valid to send data using the associated labels.

4. Notification on Label Error

This section defines the Acceptable_Label_Set TLV to support Notification on Label Error per [GMPLS-SIG]. An Acceptable_Label_Set TLV uses a type value of 0x0907. The remaining contents of the TLV have the identical format as the Label_Set TLV, see Section 2.5.

Acceptable_Label_Set TLVs may be carried in NOTIFICATION messages. The procedures for defining an Acceptable Label Set follow the procedures for defining a Label Set, see Section 2.5.1. Specifically, an Acceptable Label Set is defined via one or more Acceptable_Label_Set TLVs. Specific labels/subchannels can be added to or excluded from an Acceptable Label Set via Action zero (0) and one (1) TLVs respectively. Ranges of labels/subchannels can be added to or excluded from an Acceptable Label Set via Action two (2) and three (3) TLVs respectively. When the Acceptable_Label_Set TLVs only

list labels/subchannels to exclude, this implies that all other labels are acceptable.

The inclusion of Acceptable_Label_Set TLVs is optional. If included, the NOTIFICATION message SHOULD contain a "Routing problem/Unacceptable label value" indication. The absence of Acceptable_Label_Set TLVs does not have any specific meaning.

5. Explicit Label Control

The Label ER-Hop is defined as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|0|          0x0806           |      Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|L|U|      Reserved             |   Label                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Label (continued)                       |
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

See [GMPLS-SIG] for a description of L, U and Label parameters.

5.1. Procedures

The Label ER-Hop follows a ER-Hop containing the IP address, or the interface identifier [MPLS-UNNUM], associated with the link on which it is to be used. The preceding ER-Hop must be strict. Up to two label ER-Hops may be present, one for the downstream label and one for the upstream label. The following SHOULD result in "Bad EXPLICIT_ROUTE" errors:

- If the first label ER-Hop is not preceded by a ER-Hop containing an IP address, or a interface identifier [MPLS-UNNUM], associated with an output link.
- For a label ER-Hop to follow a ER-Hop that has the L-bit set
- On unidirectional LSP setup, for there to be a label ER-Hop with the U-bit set
- For there to be two label ER-Hops with the same U-bit values

To support the label ER-Hop, a node must check to see if the ER-Hop following it's associate address/interface is a label ER-Hop. If it is, one ER-Hop is examined for unidirectional LSPs and two ER-Hops for bidirectional LSPs. If the U-bit of the ER-Hop being examined is

clear (0), then value of the label is copied into a new Label_Set TLV. This Label_Set TLV MUST be included on the corresponding outgoing MAPPING message.

If the U-bit of the ER-Hop being examined is set (1), then value of the label is label to be used for upstream traffic associated with the bidirectional LSP. If this label is not acceptable, a "Bad EXPLICIT_ROUTE" error SHOULD be generated. If the label is acceptable, the label is copied into a new Upstream Label TLV. This Upstream Label TLV MUST be included on the corresponding outgoing MAPPING message.

After processing, the label ER-Hops are removed from the ER.

Note an implication of the above procedures is that the label ER-Hop should never be the first ER-Hop in a newly received message. If the label ER-Hop is the the first ER-Hop an a received ER, then it SHOULD be treated as a "Bad strict node" error.

Procedures by which an LSR at the head-end of an LSP obtains the information needed to construct the Label ER-Hop are outside the scope of this document.

6. Protection TLV

The use of the Protection TLV is optional. The TLV is included to indicate specific protection attributes of an LSP.

The format of Protection Information TLV is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|          0x0908           |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|S|                  Reserved                     | Link Flags|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

See [GMPLS-SIG] for a description of parameters.

6.1. Procedures

Transit nodes processing a REQUEST message containing a Protection TLV MUST verify that the requested protection can be satisfied by the outgoing interface or tunnel (FA). If it cannot, the node MUST generate a NOTIFICATION message, with a "Routing problem/Unsupported Link Protection" indication.

7. Acknowledgments

This draft is the work of numerous authors and consists of a composition of a number of previous drafts in this area. A list of the drafts from which material and ideas were incorporated follows:

draft-saha-rsvp-optical-signaling-00.txt
draft-lang-mpls-rsvp-oxc-00.txt
draft-kompella-mpls-optical-00.txt
draft-fan-mpls-lambda-signaling-00.txt

Valuable comments and input were received from a number of people, notably Adrian Farrel.

8. Security Considerations

This draft introduce no new security considerations to [CR-LDP].

9. References

[CR-LDP] Jamoussi et al., "Constraint-Based LSP Setup using LDP", draft-ietf-mpls-cr-ldp-05.txt, Feb., 2001.

[MPLS-HIERARCHY] Kompella, K., and Rekhter, Y., "LSP Hierarchy with MPLS TE", Internet Draft, draft-ietf-mpls-lsp-hierarchy-02.txt, Feb., 2001.

[MPLS-UNNUM] Kompella, K., Rekhter, Y., "Signalling Unnumbered Links in CR-LDP", Internet Draft, draft-ietf-mpls-crldp-unnum-01.txt, February 2001

[GMPLS-RSVP] Ashwood-Smith, P. et al, "Generalized MPLS Signaling - RSVP-TE Extensions", Internet Draft, draft-ietf-mpls-generalized-rsvp-te-01.txt, February 2001.

[GMPLS-SIG] Ashwood-Smith, P. et al, "Generalized MPLS - Signaling Functional Description", Internet Draft, draft-ietf-mpls-generalized-signaling-02.txt, February 2001.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," RFC 2119.

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