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Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Signaling Procedure for Resource Sharing-based LSP Setup/Teardown

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Abstract

Generalized Multiprotocol Label Switching (GMPLS) defines a set of protocols for the creation of Label Switched Paths (LSPs) in various switching technologies. It can be used for different types of switching technologies.

This document compliments existing standards by explaining the missing pieces of information during the Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) signaling procedure in support of resource sharing-based LSP setup/teardown in GMPLS-controlled circuit networks.

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1. Introduction

Generalized Multiprotocol Label Switching (GMPLS) [RFC3945] defines a set of protocols, including Open Shortest Path Fist - Traffic Engineering (OSPF-TE) [RFC4203] and Resource ReserVation Protocol - Traffic Engineering (RSVP-TE) [RFC3473]. These protocols can be used to create Label Switched Paths (LSPs) in a number of deployment scenarios with various transport technologies. The GMPLS protocol set extends MPLS, which supports only Packet Switch Capable (PSC) and Layer 2 Switch Capable interfaces (L2SC), to also cater for interfaces capable of Time Division Multiplexing (TDM), Lambda Switching and Fiber Switching.

In MPLS networks, in order to avoid double booking of resource during the process of LSP restoration or LSP re-optimization, the Make-Before-Break (MBB) exploiting the Shared-Explicit (SE) reservation style can be employed, as specified in [RFC3209]. This method is also used in GMPLS-controlled networks [RFC4872] [RFC4873] for end-to-end and segment recoveries of LSPs. This was further generalized to support resource sharing oriented applications in MPLS networks as well as non-LSP contexts, as specified in [RFC6780].

Due to the fact that the features of GMPLS-controlled networks (specifically for TDM, LSC and FSC), are not identical to that of the MPLS networks, additional considerations for resource sharing based LSP association are needed. For example, in MPLS networks, label has no meaning/match in the data plane but this is not the case in GMPLS-controlled circuit networks, such as Optical Transport Network (OTN) and Wavelength-Switched Optical Networks (WSON), where the label matches the resource used in the data plane. So, during the signaling procedure for resource sharing based LSP setup/teardown, the behaviors of the nodes along the path may be different from that in the MPLS networks as well as the effect it may has upon the traffic delivery. Some other issues are also discussed in Section 2.

The purpose of this draft is to describe the signaling process for resource sharing-based LSP setup/teardown for GMPLS-based circuit networks. This includes the node behavior description, besides clarifying some un-discussed points for this process. Two typical examples mentioned in this draft are LSP restoration and LSP re-optimization, where it is desirable to share resources. This draft does not define any RSVP-TE extensions. If necessary, discussions may be provided to identify potential extensions to the existing RSVP-TE protocol. It is expected that the extensions, if there is any, will be addressed in separate drafts.

2. Problem Statement

```
                           +-----+      +------+
                           |  F  +------+  G   +-------+
                           +--+--+      +------+       |
                              |                        |
                              |                        |
    +-----+    +-----+     +--+--+      +-----+     +--+--+
    |  A  +----+  B  +-----+  C  +--X---+  D  +-----+  E  |
    +-----+    +-----+     +-----+      +-----+     +-----+
```

Figure 1: A Simple OTN Network

Using the network shown in Figure 1 as an example, LSP1 (A-B-C-D-E) is the working LSP and it allows for resource sharing when the LSP is dynamically rerouted due to link failure. Upon detecting the failure of a link along the LSP1, e.g. Link C-D, node A needs to decide to which alternative path it will establish to reroute the traffic. In this case, A-B-C-F-G-E is chosen as the alternative path and the resource on the path segment A-B-C is re-used by this to-be-established path. Since this is an OTN network, different from packet-switching network, the label has a mapping into the data plane resource used and also the nodes along the path needs to send triggering commands to data plane nodes for setting up cross-connection accordingly during the RSVP-TE signaling process. So, the following issues are left un-described in the existing standards for resource sharing based LSP setup/teardown in GMPLS-controlled circuit networks:

o The purpose of using SE can still be fulfilled?

As described in [RFC3209], the purpose of make before break (MBB) is to ''not disrupt traffic or adversely impact network operations while TE tunnel rerouting is in progress''. Due to the nature of the GMPLS-controlled circuit networks, the first point may not be able to be fulfilled under certain scenarios. Thus, the name ''make before break'' may no longer holds true and worth discussion.

o Is the current defined MBB method sufficient in support of resource shared-based LSP setup/teardown?

In [RFC3209], the MBB method assumes the old and new LSPs share the same tunnel ID (i.e., sharing the same source and destination nodes). [RFC4873] does not impose this constraint but limit the resource sharing usage in LSP recoveries only. [RFC6780] generalizes the resource sharing application, based on the ASSOCIATION object, to be useful in MPLS networks as well as in non-LSP association such as Voice Call Waiting. Recently, there are also requirements to generalize resource sharing of LSP with different tunnel IDs, such as the one mentioned in [PCEP-RSO] and LSPs with LSP-stitching across multi-domains. Thus, how the signaling process can make intermediate nodes be aware of this resource sharing constraint and behavior accordingly is an issue that needs to be described and discussed.

O Other issues such as what is the reservation style assigned to the original LSP, and what is the node behavior during the traffic reversion, in the GMPLS-controlled circuit networks, are missing and should be explained.

3. RSVP-TE Signaling Procedure for Resource Sharing-based LSP Setup/Teardown

This section describes the signaling flow for resource sharing-based LSP setup/teardown in GMPLS-controlled circuit networks.

For LSP restoration upon failure, as explained in Section 11 of [RFC4872], the purpose of using MBB is to re-use existing resource. Thus, the behavior of the intermediate nodes during rerouting process will not impact on traffic since it has been interrupted due to the already broken working LSP.

However, for the following two cases, the behavior of intermediate nodes may impact the traffic delivery: (1) LSP reversion; (2) LSP optimization. Another dimension that needs separate attention is how to correlate the two LSPs sharing resource. For the ones sharing same tunnel ID, the majority description is provided in existing standards [RFC3209] [RFC4872]. For the ones with different Tunnel IDs, additional extensions are needed and discussed in this section.

3.1. LSPs with the Identical Tunnel ID

For this type of LSP resource sharing, SE flag and ASSOCIATION object are used together. The former is to enable sharing and the object is to identify the two correlated LSPs.

As a first step, in order to allow resource sharing, the original LSP setup should explicitly carry the SE flag in the SESSION_ATTRIBUTE object during the initial LSP setup, irrespective of the purpose of resource sharing.

The basic signaling procedure for alternative LSP setup has been described by existing standards. In [RFC3209], it describes the basic MBB signaling flow for MPLS-TE networks. [RFC4872] adds additional information when using MBB for LSP rerouting.

As mentioned before, for LSP setup/teardown in GMPLS-controlled circuit networks, the network elements along the path need to send cross-connection setup/teardown commands to data plane node(s) either during the PATH message forwarding phrase or the RESV message forwarding phrase.

3.1.1. LSP Restoration Setup and Reversion

For LSP restoration, the complete signaling flow processes for both LSP restoration upon failure and LSP reversion upon link failure recovery are described.

For LSP rerouting upon working LSP failure, using the network shown in Figure 1 as an example.

Working LSP: A-B-C-D-E
Restoration LSP: A-B-C-F-G-E

The restoration LSP may be calculated by the head end nodes or a Path Computation Element (PCE) [RFC4655]. Assume that the cross connection configuration command is sent by the control plane nodes during the RESV forwarding phrase, the node behavior for setting up the alternative LSP can be categorized into the following three categories:

Table 1: Node Behavior during LSP Restoration

Category	Node Behavior during LSP Reversion
C1	Reusing existing resource on both input and output interfaces. This type of nodes only needs to book the existing resource when receiving the PATH message and no cross-connection setup command is needed when receiving the RESV message.
C2	Reusing existing resource only on one of the interfaces, either input or output interfaces and need to use new resource on the other interface. This type of nodes needs to book the resource on the interface where new resource are needed and re-use the existing resource on the other interface when it receives the PATH message. Upon receiving the RESV message, it needs to send the re-configuration the cross-connection command to its corresponding data plane node.
C3	Using new resource on both interfaces. This type of nodes needs to book the new resource when

```
         + receiving PATH and send the cross-connection setup
         + command upon receiving RESV.
---------+---------------------------------------------------------
```

As shown in Figure 2, depending on whether the resource is re-used or not, the node behaviors differ. This deviates from normal LSP setup since some nodes do not need to re-configure the cross-connection, and thus should not be viewed as an error. Also, the judgment whether the control plane node needs to send a cross-connection setup/modification command to its corresponding data plane node(s) relies on the check whether the following two cases holds true: (1) the PATH message received include a SE reservation style; (2) the PATH message identifies a LSP that sharing the same tunnel ID as the LSP to share resource with. For the second point, the processing rules and configuration of ASSOCATION object defined in [RFC4872] are followed.

```
     +---+       +---+       +---+       +---+       +---+         +---+
     | A |       | B |       | C |       | F |       | G |         | E |
     +-+-+       +-+-+       +-+-+       +-+-+       +-+-+         +-+-+
       |   PATH    |           |           |           |             |
    C1 +----------X+ C1        |           |           |             |
       |           |           |           |           |             |
       |           |   PATH    |           |           |             |
       |           +----------X+ C2        |           |             |
       |           |           |   PATH    |           |             |
       |           |           +----------X+ C3        |             |
       |           |           |           |   PATH    |             |
       |           |           |           +----------X|C3           |
       |           |           |           |           |   PATH      |
       |           |           |           |           +------------X+ C3
       |           |           |           |           |             |
       |           |           |           |           |   RESV      |
       |           |           |           |         C3+X------------+ C3
       |           |           |           |   RESV    |             |
       |           |           |        C3 +X----------+             |
       |           |           |   RESV    |           |             |
       |           |         C2+X----------+           |             |
       |           |   RESV    |           |           |             |
       |        C1 +X----------+           |           |             |
       |   RESV    |           |           |           |             |
    C1 +X----------+           |           |           |             |
```

Figure 2: Restoration LSP Setup Signaling Procedure for LSP Restoration

If the LSP rerouting is revertive, which is a common requirement in transport networks [LSP-restoration], the traffic will be reverted to the working LSP if its failure is recovered. The three types of nodes classified above also have different behaviors during the process for tearing down the alternative LSP, as explained in Table 2.

Table 2: Node Behavior during LSP Reversion

Category	Node Behavior during LSP Reversion
D1	+ Resource reused on both interfaces. + When receiving PATH-TEAR, it only deletes the alternative + LSP state info in the control plane without changing the + cross-connection.
D2	+ Resource reused on only one interface. + When receiving PATH-TEAR, it deletes the alternative path + state information in the control plane as well as release + the resource on the interface that is not re-used between + the working and Restoration LSP.
D3	+ No resource are reused. + When receiving PATH-TEAR, it deletes the state information + related to the alternative LSP as well as tears down the + cross-connection to release the resource.

Note that before the working LSP failure recovers, the LSP in the control plane is still running and also it views the data plane resource still belongs to the working LSP. However, the re-used resource also belongs to the alternative LSP and these resources are actually used by the alternative LSP. So when the working LSP recovers, it needs to fresh the signaling messages to re-establish the working LSP cross-connection. The process would be similar to that shown in Figure 2, but running along the nodes on the working LSP path (i.e., A-B-C-D-E). Note this will interrupt the traffic delivery on the alternative LSP (i.e., Making the working LSP While Breaking the alternative LSP). This point is different from that of the MPLS networks. If no traffic interruption is mandated, mechanisms to ensure that the traffic can still be delivered should be employed and is outside the scope of this document.

Figure 3 shows the signaling process of the alternative LSP teardown during the LSP reversion. Similar to that of the alternative LSP setup process, the nodes may not need to reconfigure the cross-connection and the rationale is similar to that described above. For alarm-free LSP deletion in optical networks, the mechanisms described in Section 6 of [RFC4208] should be followed.

```
     +---+       +---+       +---+       +---+       +---+         +---+
     | A |       | B |       | C |       | F |       | G |         | E |
     +-+-+       +-+-+       +-+-+       +-+-+       +-+-+         +-+-+
       |           |           |           |           |             |
       | PATHTEAR  |           |           |           |             |
    D1 +----------X+ D1        |           |           |             |
       |           |           |           |           |             |
       |           | PATHTEAR  |           |           |             |
       |           +----------X+ D2        |           |             |
       |           |           | PATHTEAR  |           |             |
       |           |           +----------X+ D3        |             |
       |           |           |           | PATHTEAR  |             |
       |           |           |           +----------X|D3           |
       |           |           |           |           |  PATHTEAR   |
       |           |           |           |           +------------X+ D3
       |           |           |           |           |             |
```
Figure 3: Tear-down of Alternative LSP for LSP Reversion

3.1.2. LSP Re-optimization Setup and Reversion

For LSP re-optimization where the new LSP and old LSPs share resource, the signaling flow for new LSP setup and old LSP teardown is similar to that are shown in Figure 2 and 3.

The issue that should be noted is the traffic will be disrupted if the new path setup process changes the cross-connection configuration of the nodes along the old LSP. If no traffic interruption is desirable, it should either ensure that the old and new LSP does not share the resource other than the source and destination nodes or using other mechanisms. This is out the scope of this draft.

3.2. LSPs with Different Tunnel IDs

For two LSPs with different Tunnel IDs, the ASSOCIATION object is used to both specify they are sharing resource (by setting ASSOCIATION type as 2) as well as identify these correlated LSPs.

There are two types: (1) sharing the common nodes, such as segment recovery, the source and destination nodes of the segment recovery LSP is the intermediate nodes along the working LSPs; (2) resource sharing is used in a generalized context (such as multi-layer or multi-domain networks); it may result in either sharing source nodes in common, or destination nodes in common, or non end points in common, if viewed from one domain’s perspective. The path computation can either be performed by the source node or edge nodes for the path/path segment or carried out by the PCE, such as the one explained in [PCEP-RSO]. This draft does not impose any constraint with regard to path computation.

In [RFC4873], it only considers resource sharing for LSP segment recovery. The ASSOCIATION object configuration is limited. [RFC6780] extends the usage of ASSOCIATION objects to cover generalized resource sharing applications. The extended ASSOCIATION object is primarily defined for MPLS-TP, but it can be applied in a wider scope [RFC6780]. It can be used in the second types mentioned above. The configuration and processing rules of extended ASSOCIATION object defined in [RFC6780] should be obeyed. The only issue that need pay attention to is that uniqueness of LSP association for the second type should be guaranteed when crossing the layer or domain boundary. The mechanisms for how to ensure so are outside of the scope of this document.

Other than this, the signaling flow for this type of resource sharing is similar to description provided in Section 3.1.1. Similar to what is discussed in previous sections, the traffic delivery may be interrupted. Depending on whether the short traffic interruption is acceptable or not, additional mechanisms may needed and are outside of the scope of this draft.

4. Security Considerations

This draft does not incur any new security issues other than those already covered in [RFC3209] [RFC4872] [RFC4873] and [RFC6780].

5. IANA Considerations

This informational document does not make any requests for IANA action.

6. References

6.1. Normative References

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6.2. Informative References

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