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RSVP-TE Signaling Extensions in support of Flexi-grid DWDM networks

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Abstract

This memo describes the extensions to the Resource reSerVation Protocol Traffic Engineering (RSVP-TE) signaling protocol to support Label Switched Paths (LSPs) in a GMPLS-controlled network that includes devices using the flexible optical grid.

Status of this Memo

Copyright Notice

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1. Introduction

[G.694.1] defines the Dense Wavelength Division Multiplexing (DWDM) frequency grids for Wavelength Division Multiplexing (WDM) applications. A frequency grid is a reference set of frequencies used to denote allowed nominal central frequencies that may be used for defining applications that utilize WDM transmission. The channel spacing is the frequency spacing between two allowed nominal central frequencies. All of the wavelengths on a fiber use different central frequencies and occupy a designated range of frequency.

Fixed grid channel spacing is selected from 12.5 GHz, 25 GHz, 50 GHz, 100 GHz and integer multiples of 100 GHz. But [G.694.1] also defines "flexible grids", known as "flexi-grid". The terms "frequency slot" (i.e., the frequency range allocated to a specific channel and unavailable to other channels within a flexible grid) and "slot width" (i.e., the full width of a frequency slot in a flexible grid) are introduced in [G.694.1] to define a flexible grid.

[FLEX-FWK] defines a framework and the associated control plane requirements for the Generalized Multi-Protocol Label Switching (GMPLS) [RFC3945] based control of flexi-grid DWDM networks.

[RFC6163] provides a framework for GMPLS and Path Computation Element (PCE) control of Wavelength Switched Optical Networks (WSONs), and [WSON-SIG] describes the requirements and protocol extensions for signaling to set up Label Switched Paths (LSPs) in WSONs.

This document describes the additional requirements and protocol extensions to Resource reSerVation Protocol-Traffic Engineering (RSVP-TE) [RFC3473] to set up LSPs in networks that support the flexi-grid.

2. Terminology

For terminology related to flexi-grid, please refer to [FLEX-FWK] and [G.694.1].

2.1. 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].

3. Requirements for Flexible Grid Signaling

The architecture for establishing LSPs in a flexi-grid network is described in [FLEX-FWK].

An optical spectrum LSP occupies a specific frequency slot, i.e., a range of frequencies. The process of computing a route and the allocation of a frequency slot is referred to as Routing and

Spectrum Assignment (RSA). [FLEX-FWK] describes three architectural approaches to RSA: combined RSA, separated RSA, and distributed SA. The first two approaches are referred to as "centralized SA" because both routing and spectrum (frequency slot) assignment are performed by a centralized entity before the signaling procedure.

In the case of centralized SA, the assigned frequency slot is specified in the RSVP-TE Path message during LSP setup. In the case of distributed SA, the slot width of the flexi-grid LSP is specified in the Path message, allowing the network elements to select the frequency slot to be used when they process the RSVP-TE messages.

If the capability to switch or convert the whole optical spectrum allocated to an optical spectrum LSP is not available at some nodes along the path of the LSP, the LSP is subject to the Optical "Spectrum Continuity Constraint" as described in [FLEX-FWK].

The remainder of this section states the additional requirements for signaling in a flexi-grid network.

3.1. Slot Width

The slot width is an end-to-end parameter representing how much frequency resource is requested for a flexi-grid LSP. It is the equivalent of optical bandwidth, although the amount of bandwidth associated with a slot width will depend on the signal encoding.

Different LSPs may request different amounts of frequency resource in flexible grid networks, so the slot width MUST be carried in the signaling message during LSP establishment. This enables the nodes along the LSP to know how much frequency resource has been requested (in a Path message) and has been allocated (by a Resv message) for the LSP.

3.2. Frequency Slot

The frequency slot information identifies which part of the frequency spectrum is allocated on each link for an LSP in a flexi-grid network.

This information MUST be present in a Resv message to indicate, hop-by-hop, the central frequency of the allocated resource. In combination with the slot width indicated in a Resv message (see Section 3.1) the central frequency carried in a Resv message identifies the resources reserved for the LSP (known as the frequency slot).

The frequency slot can be represented by the two parameters as follows:

```
Frequency slot = [(central frequency) - (slot width)/2] ~
                 [(central frequency) + (slot width)/2]
```

As is common with other resource identifiers (i.e., labels) in GMPLS signaling, it must be possible for the head-end node when sending a Path message to suggest or require the central frequency to be used for the LSP. Furthermore, for bidirectional LSPs, the Path message MUST be able to specify the central frequency to be used for reverse direction traffic.

As described in [G.694.1], the allowed frequency slots for the flexible DWDM grid have a nominal central frequency (in THz) defined by:

193.1 + n * 0.00625

where n is zero or a positive or negative integer.

The slot width (in GHz) is defined as:

12.5 * m

where m is a positive integer.

It is possible that an implementation supports only a subset of the possible slot widths and central frequencies. For example, an implementation could be built where the nominal central frequency granularity is 12.5 GHz (by only allowing values of n that are even) and that only supports slot widths as a multiple of 25 GHz (by only allowing values of m that are even).

Further details can be found in [FLEX-FWK].

4. Protocol Extensions

This section defines the extensions to RSVP-TE signaling for GMPLS [RFC3473] to support flexible grid networks.

4.1. Traffic Parameters

In RSVP-TE, the SENDER_TSPEC object in the Path message indicates the requested resource reservation. The FLOWSPEC object in the Resv message indicates the actual resource reservation.

As described in Section 3.1, the slot width represents how much frequency resource is requested for a flexi-grid LSP. That is, it describes the end-to-end traffic profile of the LSP. Therefore, the traffic parameters for a flexi-grid LSP encode the slot width.

This document defines new C-Types for the SENDER_TSPEC and FLOWSPEC objects to carry Spectrum Switched Optical Network (SSON) traffic parameters:

SSON SENDER_TSPEC: Class = 12, C-Type = TBD1.

SSON FLOWSPEC: Class = 9, C-Type = TBD2.

The SSON traffic parameters carried in both objects MUST have the same format as shown in Figure 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              m                |          Reserved             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: The SSON Traffic Parameters

m (16 bits): a positive integer and the slot width is specified by m*12.5 GHz.

The Reserved bits MUST be set to zero and ignored upon receipt.

4.1.1. Applicability to Fixed Grid Networks

Note that the slot width (i.e., traffic parameters) of a fixed grid defined in [G.694.1] can also be specified by using the SSON traffic parameters. The fixed grid channel spacings (12.5 GHz, 25 GHz, 50 GHz, 100 GHz and integer multiples of 100 GHz) are also the multiples of 12.5 GHz, so the m parameter can be used to represent these slot widths.

Therefore, it is possible to consider using the new traffic parameter object types in common signaling messages for flexi-grid and legacy DWDM networks.

4.2. Generalized Label

In the case of a flexible grid network, the labels that have been requested or allocated as signaled in the RSVP-TE objects are encoded as described in [FLEX-LBL]. This new label encoding can appear in any RSVP-TE object or sub-object that can carry a label.

As noted in Section 4.2 of [FLEX-LBL], the m parameter forms part of the label as well as part of the traffic parameters.

As described in Section 4.3 of [FLEX-LBL], a "compound label", constructed from a concatenation of the flexi-grid LABELs, is used when signaling an LSP that uses multiple flexi-grid slots.

4.3. Signaling Procedures

There are no differences between the signaling procedure described for LSP control in [FLEX-FWK] and those required for use in a fixed-grid network [WSON-SIG]. Obviously, the TSpec, FlowSpec, and label formats described in Sections 4.1 and 4.2 are used. The signaling procedures for distributed SA and centralized SA can be applied.

5. IANA Considerations

5.1. RSVP Objects Class Types

This document introduces two new Class Types for existing RSVP objects. IANA is requested to make allocations from the "Resource ReSerVation Protocol (RSVP) Parameters" registry using the "Class Names, Class Numbers, and Class Types" sub-registry.

Class Number	Class Name	Reference
9	FLOWSPEC	[RFC2205]
	Class Type (C-Type):	
	(TBD2) SSON FLOWSPEC	[This.I-D]

Class Number	Class Name	Reference
12	SENDER_TSPEC	[RFC2205]
	Class Type (C-Type):	
	(TBD1) SSON SENDER_TSPEC	[This.I-D]

IANA is requested to assign the same value for TBD1 and TBD2, and a value of 8 is suggested.

6. Manageability Considerations

This document makes minor modifications to GMPLS signaling, but does not change the manageability considerations for such networks. Clearly, protocol analysis tools and other diagnostic aids (including logging systems and MIB modules) will need to be enhanced to support the new traffic parameters and label formats.

7. Implementation Status

[RFC Editor Note: Please remove this entire seciton prior to publication as an RFC.]

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this Internet-Draft, and is based on a proposal described in RFC 6982 [RFC6982]. The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalog of available implementations or their features. Readers are advised to note that other implementations may exist.

According to RFC 6982, "this will allow reviewers and working groups to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit."

7.1. Centre Tecnologic de Telecomunicacions de Catalunya (CTTC)

Organization Responsible for the Implementation:
  Centre Tecnologic de Telecomunicacions de Catalunya (CTTC)
  Optical Networks and Systems Department

Implementation Name and Details:
  ADRENALINE testbed
  http://networks.cttc.es/experimental-testbeds/

Brief Description:
Experimental testbed implementation of GMPLS/PCE control plane.

Level of Maturity:
Implemented as extensions to a mature GMLPS/PCE control plane. It is limited to research / prototyping stages, but it has been used successfully for more than the last five years.

Coverage:
Support for the Tspec, FlowSpec, and label formats as described version 03 of this document. Label format support extends to the following RSVP-TE objects and sub-objects:

- Generalized Label Object
- Suggested Label Object
- Upstream Label Object
- ERO Label Subobjects

It is expected that this implementation will evolve to follow the evolution of this document.

Licensing:
Proprietary

Implementation Experience:
Implementation of this document reports no issues.
General implementation experience has been reported in a number of journal papers. Contact Ramon Casellas for more information or see

http://networks.cttc.es/publications/?search=GMPLS&research_area=optical-networks-systems

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Interoperability:
No report.

8. Acknowledgments

This work was supported in part by the FP-7 IDEALIST project under grant agreement number 317999.

9. Security Considerations

This document introduces no new security considerations to [RFC3473].

See also [RFC5920] for a discussion of security considerations for GMPLS signaling.

10. References

10.1. Normative References

[RFC2119] S. Bradner, "Key words for use in RFCs to indicate requirements levels", RFC 2119, March 1997.

[RFC3473] L. Berger, Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Extensions", RFC 3473, January 2003.

[G.694.1] ITU-T Recommendation G.694.1 (revision 2), "Spectral grids for WDM applications: DWDM frequency grid", February 2012.

[FLEX-LBL] King, D., Farrel, A. and Y. Li, "Generalized Labels for the Flexi-Grid in Lambda Switched Capable (LSC) Label Switching Routers", draft-ietf-ccamp-flexigrid-lambda-label, work in progress.

10.2. Informative References

[RFC3945] Mannie, E., "Generalized Multi-Protocol Label Switching (GMPLS)" Architecture, RFC3945, October 2004.

[RFC2205] Braden, R., Zhang L., Berson, S., Herzog, S. and S. Jamin, "Resource ReSeRvation Protocol (RSVP) - Version 1, Functional Specification", RFC2205, September 1997.

[RFC5920] L. Fang et al., "Security Framework for MPLS and GMPLS Networks", RFC 5920, July 2010.

[RFC6163] Y. Lee, G. Bernstein and W. Imajuku, "Framework for GMPLS and Path Computation Element (PCE) Control of Wavelength Switched Optical Networks (WSONs)", RFC 6163, April 2011.

[RFC6982] Sheffer, Y. and A. Farrel, "Improving Awareness of Running Code: The Implementation Status Section", RFC 6982, July 2013.

[RFC Editor Note: This reference can be removed when Section 7 is removed]

[FLEX-FWK] Gonzalez de Dios, O, Casellas R., Zhang, F., Fu, X., Ceccarelli, D., and I. Hussain, "Framework and Requirements for GMPLS based control of Flexi-grid DWDM networks", draft-ietf-ccamp-flexi-grid-fwk, work in progress.

[WSON-SIG] G. Bernstein, Sugang Xu, Y. Lee, G. Martinelli and Hiroaki Harai, "Signaling Extensions for Wavelength Switched Optical Networks", draft-ietf-ccamp-wson-signaling, work in progress.

11. Contributors' Addresses

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