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RSVP-TE Signaling Extensions in Support of Flexi-Grid
Dense Wavelength Division Multiplexing (DWDM) Networks

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

This is an Internet Standards Track document.

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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 frequencies.

Fixed-grid channel spacing is selected from 12.5 GHz, 25 GHz, 50 GHz, 100 GHz, and integer multiples of 100 GHz. Additionally, [G.694.1] defines "flexible grids", also 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.

[RFC7698] defines a framework and the associated control-plane requirements for the GMPLS-based [RFC3945] 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 [RFC7689] 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 [RFC7698] 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 [RFC7698].

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). [RFC7698] describes three architectural approaches to RSA: combined RSA, separated RSA, and distributed SA. The first two approaches are referred to as "centralized SA", because routing (i.e., path determination) and spectrum assignment (i.e., selection of frequency slots) are both performed by a centralized entity prior to 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 [RFC7698].

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 how much 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 two parameters, as follows:

$$\text{Frequency slot} = [(\text{central frequency}) - (\text{slot width})/2] \sim [(\text{central frequency}) + (\text{slot width})/2]$$

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 can be built that is

1. limited to have a nominal central frequency granularity of 12.5 GHz, by only allowing values of n that are even, and
2. further limited to only support slot widths of 25 GHz, by only allowing values of m that are even.

Further details can be found in [RFC7698].

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 Class Types (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 = 8.

SSON FLOWSPEC: Class = 9, C-Type = 8.

The SSON traffic parameters carried in both objects MUST have the format shown in Figure 1.

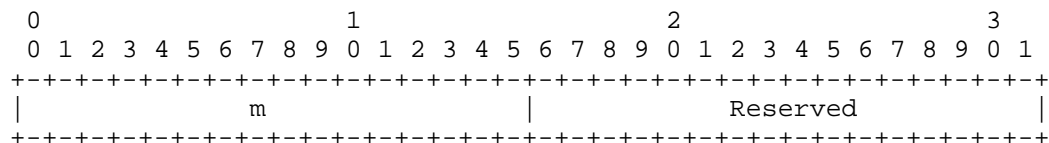


Figure 1: The SSON Traffic Parameters

m (16 bits): a positive integer; 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 [RFC7699]. 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 [RFC7699], the *m* parameter forms part of the label as well as part of the traffic parameters.

As described in Section 4.3 of [RFC7699], 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 procedures described for LSP control in [RFC7698] and those required for use in a fixed-grid network [RFC7689]. 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.

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