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GMPLS OSPF-TE Extensions in support of Flexible-Grid in DWDM Networks

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Status of this Memo

Abstract

This memo describes the OSPF-TE extensions in support of GMPLS control for flexible-grid in DWDM networks.

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].

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1. Introduction

[G.694.1v1] defines the Dense Wavelength Division Multiplexing (DWDM) frequency grids for 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. The channel spacing, i.e. the frequency spacing between two allowed nominal central frequencies could be 12.5 GHz, 25 GHz, 50 GHz, 100 GHz and integer multiples of 100 GHz as defined in [G.694.1v1]. All of the wavelengths on a fiber should use different central frequencies and occupy a fixed bandwidth of frequency.

[G.FLEXIGRID], an updated version of [G.694.1v1] will be consented in December 2011 in support of flexible-grids. The terms "frequency slot (The frequency range allocated to a channel and unavailable to other channels within a flexible-grid)" and "slot width" (the full width of a frequency slot in a flexible-grid) are introduced to address flexible-grids. A channel is represented as a LSC (Lambda

Switching Capable) LSP in the control plane, i.e. a LSC LSP should occupy a frequency slot on each fiber it traverses. In the case of flexible-grid, different LSC LSPs may have different slot width on a fiber, i.e. the slot width is flexible on a fiber.

[WSON-OSPF] defines the OSPF-TE extensions for WSON networks, which focuses on the fixed grids of DWDM. [GEN-OSPF] defines OSPF-TE extensions in support of the general network element constraints under the control of GMPLS. This document describes the additional requirements and extensions of routing protocol brought by flexible-grid.

This document uses the fiber link model which is shown in [FLEXIBLE-REQ] to describe the requirement and extensions for routing. The flexible-grid related terminologies can also refer to [FLEXIBLE-REQ].

2. Terminology

Flexible Grid: See [FLEXIBLE-REQ].

Frequency Slot Width: See [FLEXIBLE-REQ].

Frequency Range: See [FLEXIBLE-REQ].

SSON: Spectrum-Switched Optical Networks; See [FLEXIBLE-REQ].

LSC SS-LSP or flexi-LSP (Lambda Switch Capable Spectrum-Switched Label Switched Path): a control plane construct that represents a data plane connection in which the switching involves a frequency slot of a variable (flexible) slot width. The mapped client signal is transported over the slot width, using spectrum efficient modulations such as Coherent Optical Orthogonal Frequency Division Multiplexing (CO-OFDM).

3. Requirements for Flexible-grid Routing

As described in [FLEXIBLE-REQ], the main changes for routing brought by flexible-grid are related to the DWDM links.

3.1. Available Frequency Ranges on the Flexible-Grid DWDM Links

In the case of flexible-grids, the central frequency steps from 193.1 THz with 6.25 GHz granularity. The central frequency is calculated as follows:

Central Frequency = 193.1 THz + n * 0.00625 THz

Where n is a positive or negative integer including 0.

Different LSC LSPs could occupy frequency slots with different slot width. The frequency slot width of a LSC LSP is defined as follows:

Slot width = 0.0125 THz * m

Where m is a positive integer.

The frequency slot of a LSP can be determined by the slot width and central frequency as follows.

Lowest frequency = (central frequency) - (slot width)/2

= (193.1 + n * 0.00625) - (0.0125 * m)/2

= (193.1 + (n - m) * 0.00625) THz;

Highest frequency = (central frequency) + (slot width)/2

= (193.1 + n * 0.00625) + (0.0125 * m)/2

= (193.1 + (n + m) * 0.00625) THz;

On a DWDM link, the frequency slots must not overlap with each other. However, the border frequencies of two frequency slots may be the same frequency, i.e. the highest frequency of a frequency slot may be the lowest frequency of the next frequency slot.

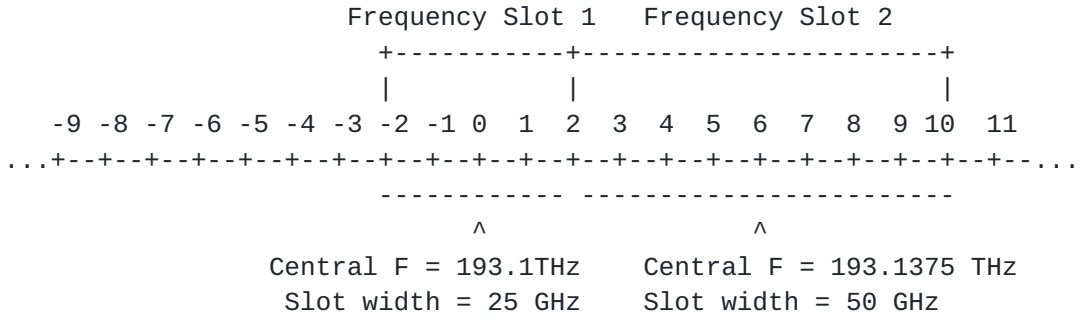


Figure 1 - Two Frequency Slots on a link

Figure 1 shows two adjacent frequency slots on a link. The highest frequency of frequency slot 1 denoted by n=2 is the lowest frequency

of slot 2. In this example, it means that the frequency range from n=-2 to n=10 is occupied and is unavailable to other LSC LSPs.

Hence, the available frequency ranges should be advertised for the flexible-grid DWDM links. A set of non-overlapping available frequency ranges SHOULD be disseminated in order to allow efficient resource management of Flexible-grid DWDM links and RSA procedures which are described in section 4 of [FLEXIBLE-REQ].

3.2. Comparison with Fixed-grid DWDM Links

In case of fixed-grid DWDM links, each wavelength has a pre-defined central frequency and all the wavelengths occupy the same frequency range (channel spacing). Hence all the wavelengths in the DWDM links can be identified uniquely and the status (available or not) of the wavelengths can be advertised through routing protocol.

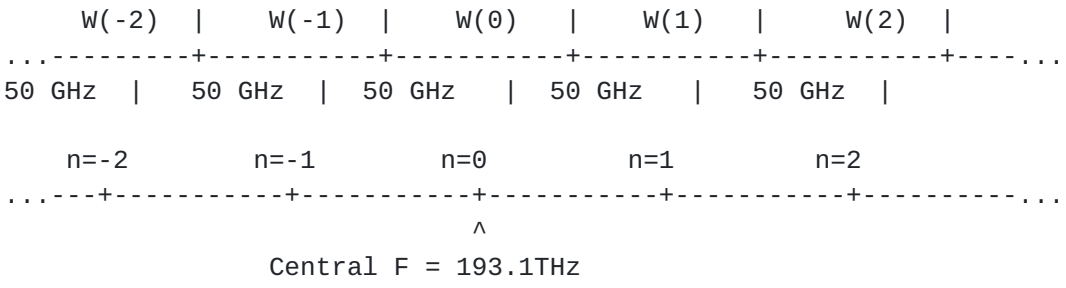


Figure 2 - A Link supports Fixed Wavelengths with 50 GHz Channel Spacing

Figure 2 shows a link that supports fixed-grid with 50 GHz channel spacing. The central frequencies of the wavelengths are pre-defined by 'n' and each wavelength occupies a fixed 50 GHz frequency range as described in [G.694.1v1].

Different from the fixed-grid DWDM links, the slot width of the wavelengths are flexible on a flexible-grid DWDM link as described in section 2.1, i.e., the value of m in the formula is uncertain before a frequency slot is allocated. So, the available frequency ranges instead of the specific "wavelengths" should be advertised for a flexible-grid DWDM link.

4. Extensions

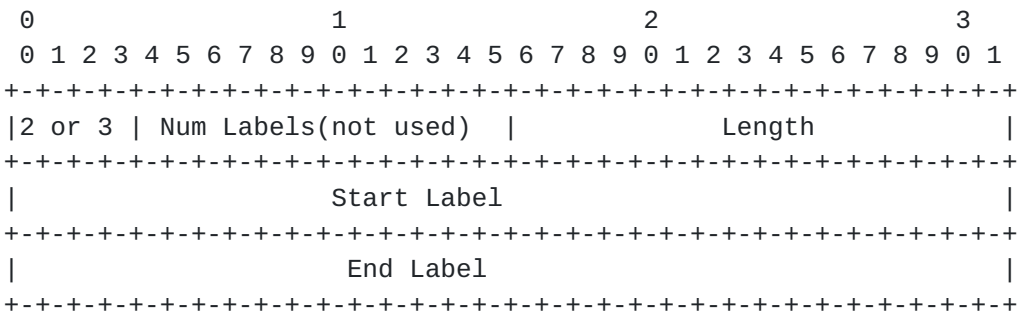
As described in [FLEXIBLE-REQ], the network connectivity topology constructed by the links/nodes and node capabilities are the same as

WSON which can be advertised by GMPLS routing protocol (refer to section 6.2 of [RFC6163]. In case of flexible-grid, the available frequency ranges instead of the specific ''wavelengths'' should be advertised for the link, which is different from the fixed grid DWDM. This section defines the GMPLS OSPF-TE extensions in support of advertising the available frequency ranges for the flexible-grid DWDM links.

4.1. Available Labels Set sub-TLV

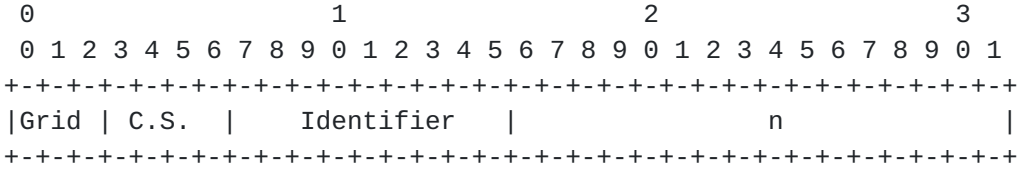
As described in section 2.1, the available frequency ranges other than the available frequency slots should be advertised for the flexible-grid DWDM links. The Available Labels Set sub-TLV defined in [GEN-OSPF] can be re-used to advertise the available frequency ranges for the flexible-grid DWDM links.

To make the encoding efficiently, the inclusive/exclusive label ranges format of Available Labels Set sub-TLV defined in [GEN-OSPF] can be used for specifying the frequency ranges of the flexible-grid DWDM links.



Note that it needs multiple Available Labels Set sub-TLVs if there are multiple discontinuous frequency ranges on a link.

The fields of Start Label and End Label specify the lowest frequency and highest frequency of a frequency range. The label format defined in [FLEXIBLE-SIG] shown below can be used to encode the Start Label and End Label:



In case of Grid=1 (ITU-T DWDM), a new value of C.S. is defined for flexible 6.25 GHz grid.

If the C.S. is 6.25 GHz in an Available Labels Set sub-TLV, it means that the corresponding link supports flexible-grid and the Start Label/End Label specifies the frequency range of the link.

[Editors' Note: the other formats of Label set (e.g., Inclusive/Exclusive Label Lists and Bitmap Label Set) can also be used to specify the frequency ranges for the flexible-grid DWDM links.]

4.2. Examples

Figure 3 shows an example of a flexible-grid DWDM link which is traversed by two LSC LSPs.

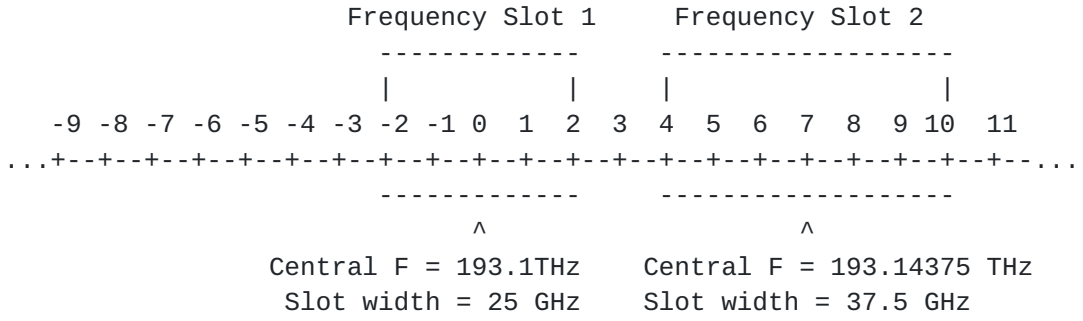


Figure 3 - Two Frequency Slots on a Link

The available frequency resource of the link could be advertised as follows:

<Available Labels> sub-TLV:

o Exclusive Range 1: [Start label = 193.1 + (-2)*0.00625,

End Label = 193.1 + 2*0.00625]

o Exclusive Range 2: [Start label = 193.1 + 4*0.00625,

End Label = 193.1 + 10*0.00625]

It is noted that the central frequency denoted by n=3 is available for a LSC LSP with 12.5 GHz slot width request but unavailable for a LSC LSP with a wider slot width request.

- If a LSC LSP which requires a 12.5 GHz width frequency slot is requested on this link, the central frequency denoted by n=3 is available because the corresponding frequency slot [n=2, n=4] dose not overlap the existing LSPs (the unavailable frequency ranges is [n=-2, n=2] and [n=4, n=10]).

- If a LSC LSP which requires a 25 GHz width frequency slot is requested on this link, the central frequency denoted by n=3 is unavailable because the corresponding frequency slot [n=1, n=5] overlaps the unavailable central frequencies (the unavailable frequency ranges is [n=-2, n=2] and [n=4, n=10]).

5. IANA Considerations

TBD.

6. Security Considerations

This document does not introduce any further security issues other than those discussed in [RFC3630], [RFC4203].

7. References

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