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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 flexi-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] has been consented in December 2011 in support of flexi-grids. The terms "frequency slot (The frequency range allocated to a channel and unavailable to other channels within a flexi-grid)" and "slot width" (the full width of a frequency slot in a flexi-grid) are introduced to address flexi-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 flexi-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 flexi-grid.

This document uses the DWDM link model which is shown in [SSON-FWK] to describe the requirement and extensions for routing. The flexi-grid related terminologies can also refer to [SSON-FWK].

2. Terminology

Flexi-grid: See [SSON-FWK].

Slot Width: See [SSON-FWK].

Frequency Range: See [SSON-FWK].

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

Flexi-LSP: See [SSON-FWK].

3. Requirements for Flexi-grid Routing

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

3.1. Available Frequency Ranges

In the case of flexi-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 flexi-LSPs could occupy frequency slots with different slot width. The frequency slot width of a flexi-LSP is defined as follows:

Slot width = 0.0125 THz * m

Where m is a positive integer.

The frequency slot of a flexi-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.

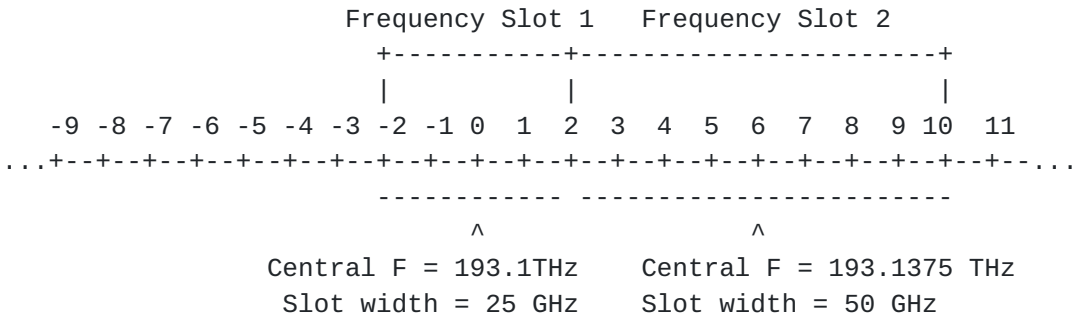


Figure 1 - Two Frequency Slots on a link

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 flexi-LSPs.

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

3.2. Application Compliance Considerations

As described in [G.FLEXIGRID], devices or applications that make use of the flexi-grid may not have to be capable of supporting every possible slot width or position. In other words, applications may be defined where only a subset of the possible slot widths and positions are required to be supported.

For example, an application could be defined where the nominal central frequency granularity is 12.5 GHz (by only requiring values of n that are even) and that only requires slot widths as a multiple of 25 GHz (by only requiring values of m that are even).

Hence, the following information should be advertised for a flexi-grid DWDM link:

o Central frequency granularity: a multiple of 6.25 GHz.

o Slot width granularity: a multiple of 12.5 GHz.

o Slot width range: the minimal and maximal slot width supported by a port.

The combination of slot width range and slot width granularity can be used to determine the slot widths set supported by a port.

3.3. Comparison with Fix-grid DWDM Links

In case of fix-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.

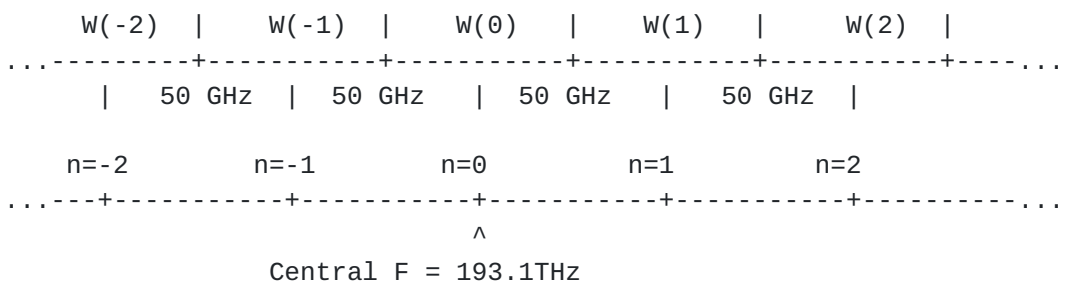


Figure 2 - A Link supports Fixed Wavelengths with 50 GHz Channel Spacing

Figure 2 shows a link that supports fix-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 fix-grid DWDM links, the slot width of the wavelengths are flexible on a flexi-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 flexi-grid DWDM link.

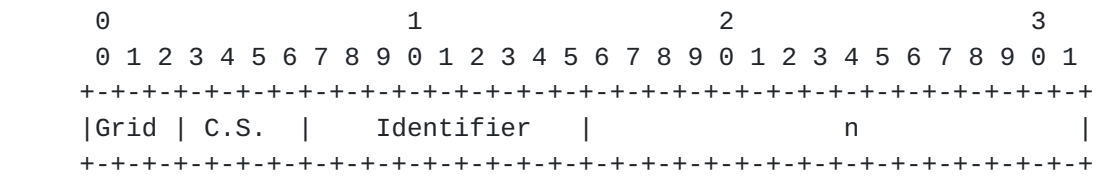
4. Extensions

As described in [SSON-FWK], 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 flexi-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 flexi-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 flexi-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 flexi-grid DWDM links.

The label format defined in [FLEXIBLE-SIG] shown below MUST be used to encode the Label fields in Available Labels Set sub-TLV:



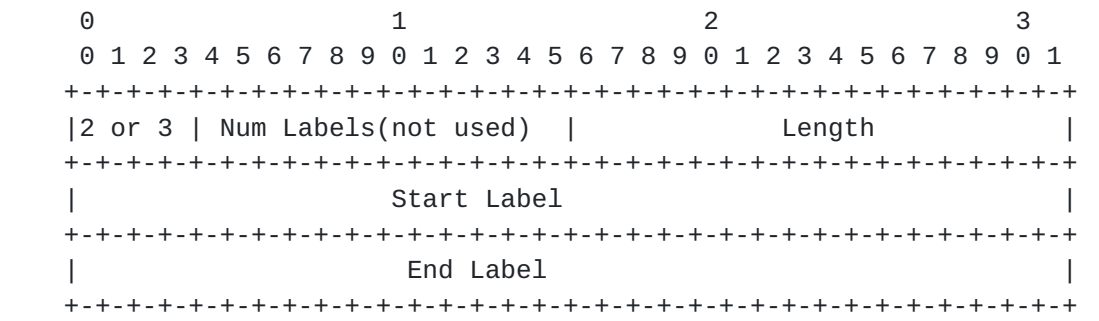
In case of Grid=1 (ITU-T DWDM), a new value of C.S. is defined for flexible grid.

If the C.S. is set to "Flexible grid" in an Available Labels Set sub-TLV, it means that the corresponding link supports flexible grid.

Note that according to the label format defined in [FLEXIBLE-SIG], for the case where the channel spacing value is set to "Flexible grid", a channel spacing of 6.25 GHz should be used in the central frequency computation formula.

4.1.1. Inclusive/Exclusive Label Range

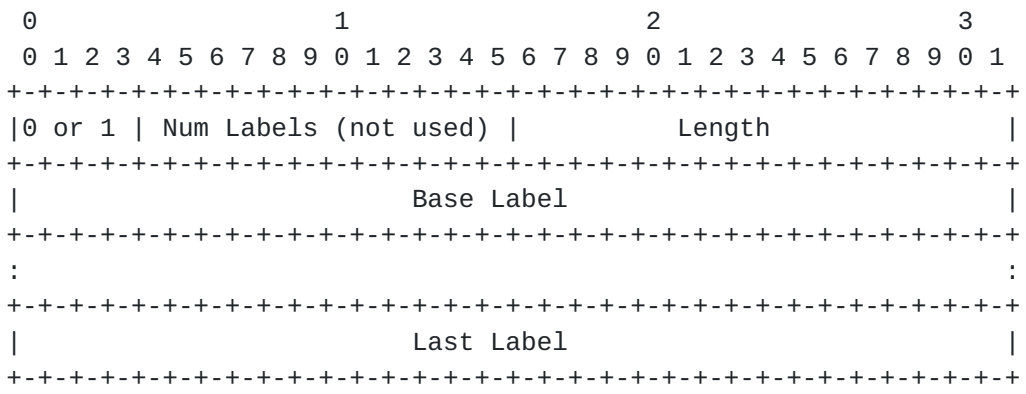
The inclusive/exclusive label ranges format of Available Labels Set sub-TLV defined in [GEN-OSPF] can be used for specifying the frequency ranges of the flexi-grid DWDM links.



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

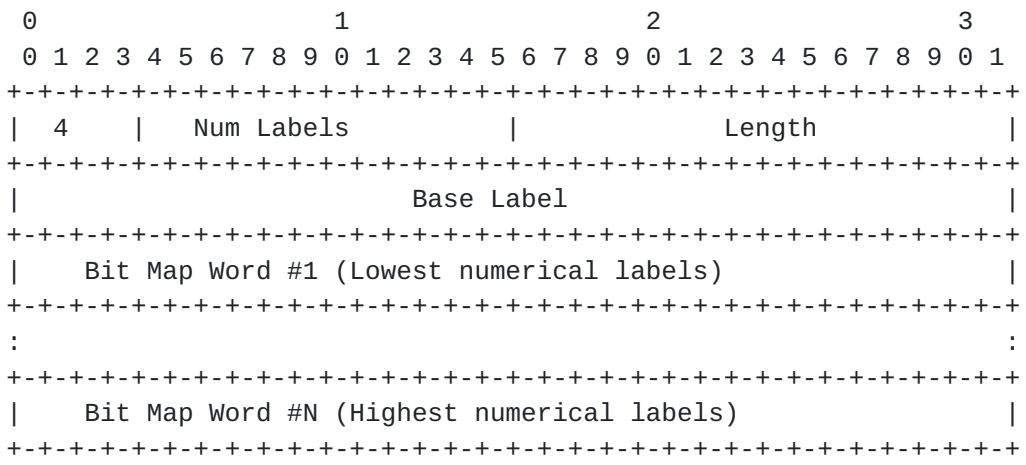
4.1.2. Inclusive/Exclusive Label Lists

The inclusive/exclusive label lists format of Available Labels Set sub-TLV defined in [GEN-OSPF] can be used for specifying the available central frequencies of the flexi-grid DWDM links.



4.1.3. Bitmap

The bitmap format of Available Labels Set sub-TLV defined in [GEN-OSPF] can be used for specifying the available central frequencies of the flexi-grid DWDM links.



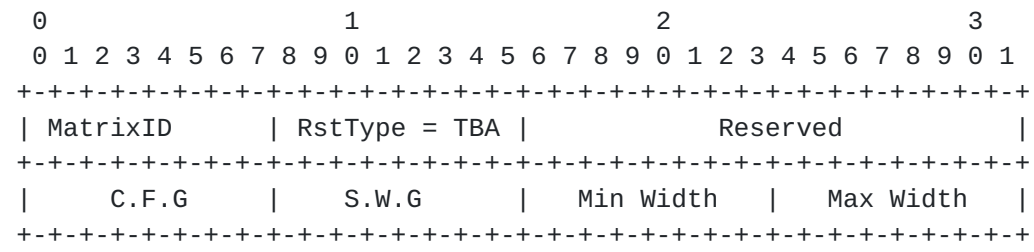
In this case, the Base Label specifies the lowest available central frequency.

Each bit in the bit map represents a particular central frequency with a value of 1/0 indicating whether the central frequency is in the set or not. Bit position zero represents the lowest central frequency and corresponds to the base label, while each succeeding bit position represents the next central frequency logically above the previous.

4.2. Extensions to Port Label Restriction sub-TLV

As described in Section 3.2, there are some restrictions on a port to support flexi-grid. Port Label Restriction sub-TLV is defined in [GEN-OSPF] that can be used to describe the label restrictions on a

port. A new restriction type, i.e. flexi-grid Restriction Type is defined here to specify the restrictions on a port to support flexi-grid.



C.F.G (Central Frequency Granularity, 8 bits): A positive integer. Its value indicates the multiple of 6.25 GHz in terms of central frequency granularity.

S.W.G (Slot Width Granularity, 8 bits): A positive integer. Its value indicates the multiple of 12.5 GHz in terms of slot width granularity.

Min Width (8 bits): A positive integer. Its value indicates the multiple of 12.5 GHz in terms of the supported minimal slot width.

Max Width (8 bits): A positive integer. Its value indicates the multiple of 12.5 GHz in terms of the supported maximal slot width.

4.3. Examples for Label Set

Figure 3 shows an example of available frequency range of a flexi-grid DWDM link.

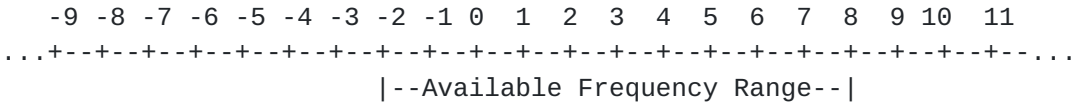


Figure 3 - Flexi-grid DWDM Link

The symbol '+' represents the allowed nominal central frequency. The symbol "--" represents a 6.25 GHz frequency unit. The number on the top of the line represents the 'n' in the frequency calculation formula (193.1 + n * 0.00625). The nominal central frequency is 193.1 THz when n equals zero.

Assume that the central frequency granularity is 6.25GHz, the label set can be encoded as follows:

Inclusive Label Range:

- Start Label = -2;
- End Label = 8.

The available central frequencies (-1, 0, 1, 2, 3, 4, 5, 6, 7) can be deduced by the Inclusive Label Range, because the Central Frequency Granularity is 6.25 GHz.

Inclusive Label Lists:

- Label 1 = -1;
- Label 2 = 0;
- Label 3 = 1;
- Label 4 = 2;
- Label 5 = 3;
- Label 6 = 4;
- Label 7 = 5;
- Label 8 = 6;
- Label 9 = 7.

Bitmap:

- Base Label = -1;
- Bitmap = 111111111(padded out to a full multiple of 32 bits)

5. IANA Considerations

This document introduces a new Restriction Type for the Port Label Restriction sub-TLV defined in [GEN-OSPF]:

Restriction Type: TBA (flexi-grid)

6. Security Considerations

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

7. References

7.1. Normative References

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[WSON-OSPF] Y. Lee and G. Bernstein, "GMPLS OSPF Enhancement for Signal and Network Element Compatibility for Wavelength Switched Optical Networks ", draft-ietf-ccamp-wson-signal-compatibility-ospf-06, September 2011.

[GEN-OSPF] Fatai Zhang, Y. Lee, Jianrui Han, G. Bernstein and Yunbin Xu, " OSPF-TE Extensions for General Network Element Constraints ", draft-ietf-ccamp-gmpls-general-constraints-ospf-te-02, September 2011.

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

[RFC6205] T. Otani and D. Li, "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, March 2011.

[SSON-FWK] F.Zhang et al, "Framework for GMPLS Control of Spectrum Switched Optical Networks ", draft-zhang-ccamp-sson-framework-00, in progress.

[FLEXIBLE-SIG] F.Zhang et al, "RSVP-TE Signaling Extensions in support of Flexible-grid", draft-zhang-ccamp-flexible-grid-rsvp-te-ext-00, in progress.

7.2. Informative References

[G.694.1v1] ITU-T Recommendation G.694.1, Spectral grids for WDM applications: DWDM frequency grid, June 2002.

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