

Network Working Group
Internet-Draft
Intended status: Standards Track

Fatai Zhang
Xiaobing Zi
Huawei
Ramon Casellas
CTTC
O. Gonzalez de Dios
Telefonica
D. Ceccarelli
Ericsson
October 24, 2011

Expires: April 24, 2012

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

[draft-zhang-ccamp-flexible-grid-ospf-ext-00.txt](#)

Status of this Memo

This Internet-Draft is submitted to IETF in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

The list of current Internet-Drafts can be accessed at <http://www.ietf.org/ietf/1id-abstracts.txt>.

The list of Internet-Draft Shadow Directories can be accessed at <http://www.ietf.org/shadow.html>.

This Internet-Draft will expire on April 24, 2012.

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](#)].

Table of Contents

1.	Introduction	2
2.	Terminology	3
3.	Requirements for Flexible-grid Routing	3
	3.1. Available Frequency Ranges on the Flexible-Grid DWDM Links	3
	3.2. Comparison with Fixed-grid DWDM Links	5
4.	Extensions	5
	4.1. Available Labels Set sub-TLV	6
	4.2. Examples	7
5.	IANA Considerations	8
6.	Security Considerations	8
7.	References	8
8.	Authors' Addresses	10

[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.

[WSN-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

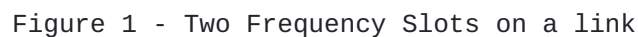
Different LSC LSPs could occupy frequency slots with different slot width. The frequency slot width of a LSC LSP is defined as follows:

Where m is a positive integer.

$$\text{Lowest frequency} = (\text{central frequency}) - (\text{slot width})/2$$

$$\text{Highest frequency} = (\text{central frequency}) + (\text{slot width})/2$$

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.



[Page 4]

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.

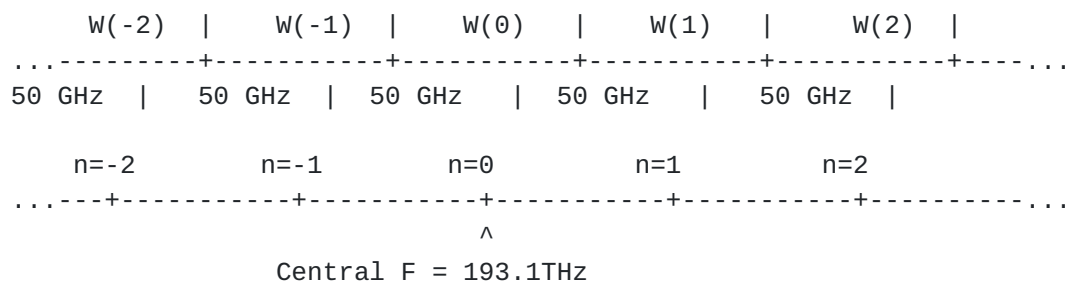


Figure 2 - A Link supports Fixed Wavelengths with 50 GHz Channel Spacing

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

WSO_N 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.

```

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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|2 or 3 | Num Labels(not used) |                               Length |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               Start Label                               |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|                               End Label                               |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

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:

```

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
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|Grid | C.S. | Identifier |                               n                               |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```


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.

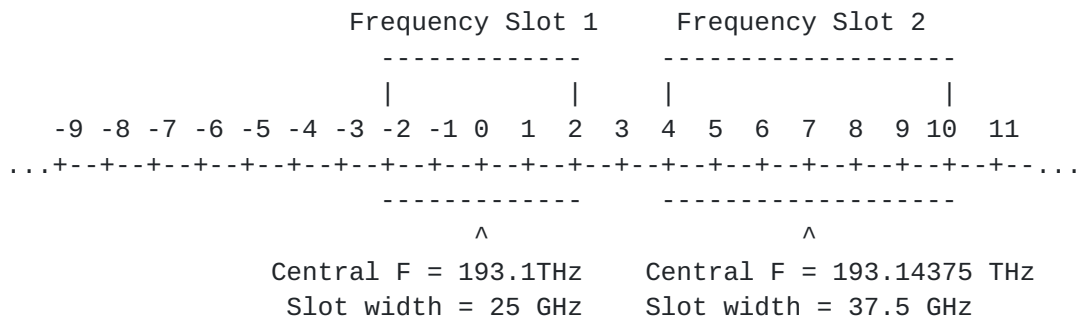


Figure 3 - Two Frequency Slots on a Link

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

<Available Labels> sub-TLV:

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

End Label = $193.1 + 2 \times 0.00625$]

o Exclusive Range 2: [Start label = $193.1 + 4 \times 0.00625$,

End Label = $193.1 + 10 \times 0.00625$]

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.

- o 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 [$n=2, n=4$] does not overlap the existing LSPs (the unavailable frequency ranges is [$n=-2, n=2$] and [$n=4, n=10$]).
- o 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

- [RFC2119] S. Bradner, "Key words for use in RFCs to indicate requirements levels", [RFC 2119](#), March 1997.
- [G.694.1v1] ITU-T Recommendation G.694.1, Spectral grids for WDM applications: DWDM frequency grid, June 2002.
- [G.FLEXIGRID] Draft revised G.694.1 version 1.3, Unpublished ITU-T Study Group 15, Question 6.
- [WSN-PCE] Y. Lee, G. Bernstein, Jonas Martensson, T. Takeda and T. Tsuritani, "PCEP Requirements for WSON Routing and Wavelength Assignment", [draft-ietf-pce-wson-routing-wavelength-05](#), July 2011.
- [WSN-SIG] G. Bernstein, Sugang Xu, Y. Lee, G. Martinelli and Hiroaki Harai, "Signaling Extensions for Wavelength Switched Optical Networks", [draft-ietf-ccamp-wson-signaling-02](#), September 2011.
- [WSN-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 (WSNs)", [RFC 6163](#), April 2011.
- [RFC6205] T. Otani and D. Li, "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", [RFC 6205](#), March 2011.
- [FLEXIBLE-REQ] F.Zhang et al, "Requirements for GMPLS Control of Flexible-grids",[draft-zhang-ccamp-flexible-grid-requirements](#), 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.

8. Authors' Addresses

Fatai Zhang
Huawei Technologies
F3-5-B R&D Center, Huawei Base
Bantian, Longgang District
Shenzhen 518129 P.R.China
Phone: +86-755-28972912
Email: zhangfatai@huawei.com

Ramon Casellas, Ph.D.
CTTC
Spain
Phone: +34 936452916
Email: ramon.casellas@cttc.es

Oscar Gonzalez de Dios
Telefonica Investigacion y Desarrollo
Emilio Vargas 6
Madrid, 28045
Spain
Phone: +34 913374013
Email: ogondio@tid.es

Daniele Ceccarelli
Ericsson
Via A. Negrone 1/A
Genova - Sestri Ponente
Italy
Email: daniele.ceccarelli@ericsson.com

Xiaobing Zi
Huawei Technologies
F3-5-B R&D Center, Huawei Base
Bantian, Longgang District
Shenzhen 518129 P.R.China
Phone: +86-755-28973229
Email: zixiaobing@huawei.com

Intellectual Property

The IETF Trust takes no position regarding the validity or scope of any Intellectual Property Rights or other rights that might be claimed to pertain to the implementation or use of the technology described in any IETF Document or the extent to which any license under such rights might or might not be available; nor does it represent that it has made any independent effort to identify any such rights.

Copies of Intellectual Property disclosures made to the IETF Secretariat and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementers or users of this specification can be obtained from the IETF on-line IPR repository at <http://www.ietf.org/ipr>

The IETF invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights that may cover technology that may be required to implement any standard or specification contained in an IETF Document. Please address the information to the IETF at ietf-ipr@ietf.org.

The definitive version of an IETF Document is that published by, or under the auspices of, the IETF. Versions of IETF Documents that are published by third parties, including those that are translated into other languages, should not be considered to be definitive versions of IETF Documents. The definitive version of these Legal Provisions is that published by, or under the auspices of, the IETF. Versions of these Legal Provisions that are published by third parties, including those that are translated into other languages, should not be considered to be definitive versions of these Legal Provisions.

For the avoidance of doubt, each Contributor to the IETF Standards Process licenses each Contribution that he or she makes as part of the IETF Standards Process to the IETF Trust pursuant to the provisions of [RFC 5378](#). No language to the contrary, or terms, conditions or rights that differ from or are inconsistent with the rights and licenses granted under [RFC 5378](#), shall have any effect and shall be null and void, whether published or posted by such Contributor, or included with or in such Contribution.

Disclaimer of Validity

All IETF Documents and the information contained therein are provided on an "AS IS" basis and THE CONTRIBUTOR, THE ORGANIZATION HE/SHE REPRESENTS OR IS SPONSORED BY (IF ANY), THE INTERNET

SOCIETY, THE IETF TRUST AND THE INTERNET ENGINEERING TASK FORCE
DISCLAIM ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT
LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION THEREIN
WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF
MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Full Copyright Statement

Copyright (c) 2010 IETF Trust and the persons identified as the
document authors. All rights reserved.

This document is subject to [BCP 78](#) and the IETF Trust's Legal
Provisions Relating to IETF Documents
(<http://trustee.ietf.org/license-info>) in effect on the date of
publication of this document. Please review these documents
carefully, as they describe your rights and restrictions with
respect to this document. Code Components extracted from this
document must include Simplified BSD License text as described in
Section 4.e of the [Trust Legal Provisions](#) and are provided without
warranty as described in the Simplified BSD License.