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Generalized Labels for the Flexi-Grid in Lambda-Switch-Capable (LSC) Label Switching Routers

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Abstract

A new flexible wavelength grid ("flexi-grid") is being developed within the ITU-T Study Group 15 to allow selection and switching of individual lambdas chosen flexibly from a detailed, fine granularity grid of available wavelengths. This document updates the definition of GMPLS lambda labels to support the flexi-grid.

This document updates RFC 3471 and updates RFC 6205.

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1. Introduction

As described in [RFC3945], GMPLS extends MPLS from supporting only Packet Switching Capable (PSC) interfaces and switching to also support four new classes of interfaces and switching that include Lambda Switch Capable (LSC).

A functional description of the extensions to MPLS signaling needed to support this new class of interface and switching is provided in [RFC3471].

[RFC3471] states that wavelength labels "only have significance between two neighbors" (Section 3.2.1.1); global wavelength semantics are not considered. [RFC6205] defines a standard lambda label format which is compliant with both the Dense Wavelength Division Multiplexing (DWDM) grid [G.694.1] and the Coarse Wavelength Division Multiplexing (CWDM) grid [G.694.2].

A flexible grid network selects its data channels as arbitrarily assigned spectral slices. Mixed bitrate transmission systems can allocate their channels with different spectral bandwidths so that the channels can be optimized for the bandwidth requirements of the particular bit rate and modulation scheme of the individual channels. This technique is regarded as a promising way to improve the network utilization efficiency and fundamentally reduce the cost of the core network.

The "flexi-grid" is being developed within the ITU-T Study Group 15 to allow selection and switching of individual lambdas chosen flexibly from a detailed, fine granularity grid of wavelengths with arbitrary spectral bandwidth [G.FLEXIGRID]. This document updates the definition of GMPLS lambda labels provided in [RFC6205] to support the flexi-grid.

This document will not be put forward for publication as an RFC before the ITU-T have completed technical development of [G.FLEXIGRID], and the encoding specified in this document will also be communicated to the ITU-T for comment before publication as an RFC.

1.1. 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 [RFC2119].

2. Overview of Flexi-Grid

[G.FLEXIGRID] extends DWDM fixed grids as defined in [G.694.1] to add support for flexible grids. The basis of the work is to allow a data channel to be formed from an abstract grid anchored at 193.1 THz and selected on a channel spacing of 6.25 GHz with a variable slot width measured in units of 12.5 GHz. Individual allocations may be made on this basis from anywhere in the spectrum, subject to allocations not overlapping.

3. Fixed Grid Lambda Label Encoding

[RFC6205] defines an encoding for a global semantic for a DWDM label based on four fields:

- Grid: used to select which grid the lambda is selected from. Values defined in [RFC6205] identify DWDM [G.694.1] and CWDM [G.694.2].

- C.S. (Channel Spacing): used to indicate the channel spacing. [RFC6205] defines values to represent spacing of 100, 50, 25 and 12.5 GHz.

- Identifier: a local-scoped integer used to distinguish different lasers (in one node) when they can transmit the same frequency lambda.

- n: a two's-complement integer to take either a positive, negative, or zero value. This value is used to compute the frequency as defined in [RFC6205] and based on [G.694.1]. The use of n is repeated here for ease of reading.

    Frequency (THz) = 193.1 THz + n * channel spacing (THz)

4. Flexi-Label Format and Values

4.1 Flexi-Label Encoding

This document defines a new generalized label encoding for use in flexi-grid systems. As with all other GMPLS lambda labels, the use of this label is known a priori. That is, since the interpretation of

all lambda labels is determined hop-by-hop, the use of this label requires that all nodes on the path expect to use this label.

For convenience, however, the label is modeled on the fixed grid label defined in [RFC6205] and briefly described in Section 3.

Figure 1 shows the format of the Flexi-Label. It is a 64 bit label.

[Editors' note: We considered the possibility of having a 40 bit label with no reserved bits, or a 48 bit label with 8 reserved bits. This would be somewhat more efficient for objects that carry multiple labels encoded as a sequence. However, since most uses of the label are in objects where the label is padded to a 32 bit boundary, there seemed little benefit.]

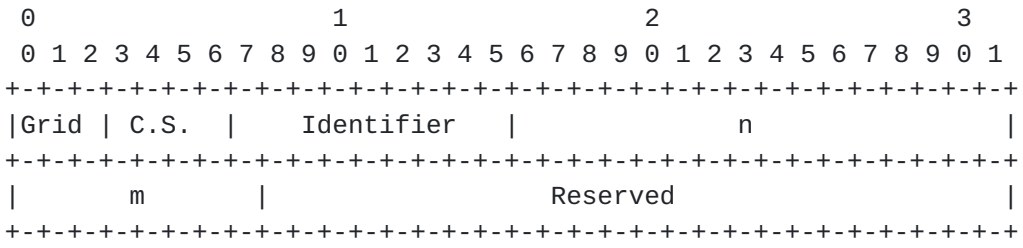


Figure 1 : The Flexi-Label Encoding

This document defines a new Grid value to supplement those in [RFC6205]:

Grid	Value
ITU-T Flex	3

Within the fixed grid network, the C.S. value is used to represent the channel spacing, as the spacing between adjacent channels is constant. While, for flexible grid situation, this field should be used to represent the channel spacing granularity/or central frequency granularity.

This document defines a new C.S. value to supplement those in [RFC6205]:

C.S(GHz)	Value
6.25	5

The meaning of the Identifier field is maintained from [RFC6205] (see also Section 3).

The meaning of n is maintained from [RFC6205] (see also Section 3).

The m field is used to identify the slot width according to the formula given in [G.FLEXIGRID] as follows:

Slot Width (GHz) = 12.5 GHz * m

The practical range of values for m is from 1 to 8 for slot widths ranging from 12.5 GHz to 100 GHz. Wider slot widths may be considered with larger values of m.

The Reserved field MUST be set to zero on transmission and SHOULD be ignored on receipt.

An implementation that wishes to use the flexi-grid MUST follow the procedures of [RFC3473] and of [RFC3471] as updated by [RFC6205]. It MUST set Grid to 3 and C.S. to 5. It MUST set Identifier to indicate the local identifier of the laser in use as described in [RFC6205]. It MUST also set n according to the formula in Section 3 (inherited unchanged from [RFC6205]). Finally,the implementation MUST set m as described in the formula stated above.

5. Manageability Considerations

This document introduces no new elements for management. That is, labels will continue to be used in the same way by the GMPLS protocols and lambda labels have the same fields as previously defined so any management tools defined to handle [RFC6205] labels will be able to handle labels as specified in this document. However, it is obvious that the management tools will have to interpret the new values and meanings of label fields as defined in this document, and management tools that may have been (unwisely) coded to expect all lambda labels to be 32 bits, will need to be updated to handle these 64 bit labels.

6. Security Considerations

[RFC6205] notes that the definition of a new label encoding does not introduces any new security considerations to [RFC3471] and [RFC3473]. That statement applies equally to this document.

For a general discussion on MPLS and GMPLS-related security issues, see the MPLS/GMPLS security framework [RFC5920].

7. IANA Considerations

IANA maintains the "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Parameters" registry that contains several subregistries.

7.1. Grid Subregistry

IANA is requested to allocate a new entry in this subregistry as follows:

Value	Grid	Reference
3	ITU-T Flex	[This.I-D]

7.2. DWDM Channel Spacing Subregistry

IANA is requested to allocate a new entry in this subregistry as follows:

Value	Channel Spacing (GHz)	Reference
5	6.25	[This.I-D]

8. Acknowledgments

Very many thanks to Lou Berger for discussions of labels of more than 32 bits.

The authors would like to thank Ben Niven-Jenkins for inspiring the choice of filename for this document.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC3471] Berger, L., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Signaling Functional Description", RFC 3471, January 2003.

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

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

[G.FLEXIGRID] Preliminary Draft revised G.694.1. Unpublished ITU-T Study Group 15, Question 6.

9.2. Informative References

[RFC3945] Mannie, E., Ed., "Generalized Multi-Protocol Label Switching (GMPLS) Architecture", RFC 3945, October 2004.

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

[G.694.2] ITU-T Recommendation G.694.2, "Spectral grids for WDM applications: CWDM wavelength grid", December 2003.

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

Appendix A. Flexi-Grid Example

Considering the network displayed in Figure 2 (reproduced from [RFC6205]) it is possible to show an example of LSP setup using the lambda labels. The figure shows Reconfigurable Optical Add/Drop Multiplexers (ROADMs) and Wavelength Cross-Connects (WXCs) that operate at the wavelength switching level as well as PXCs

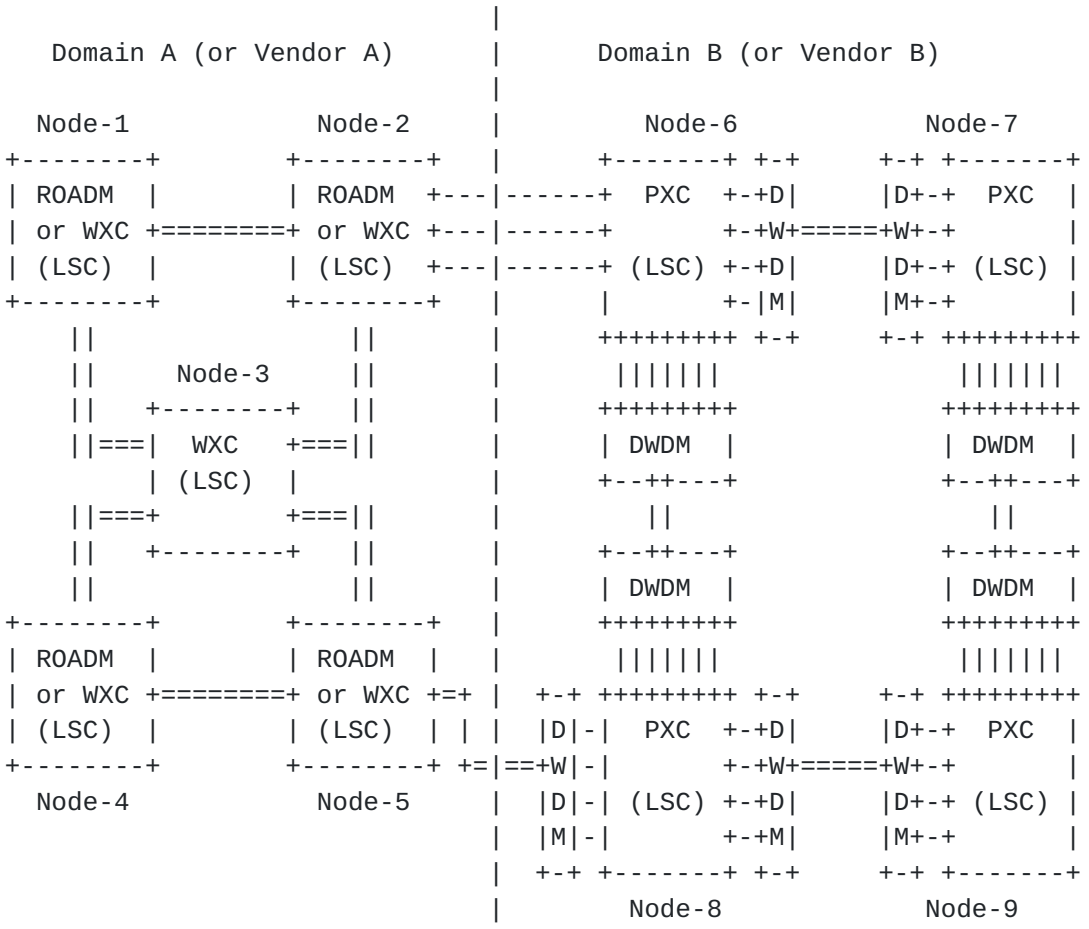
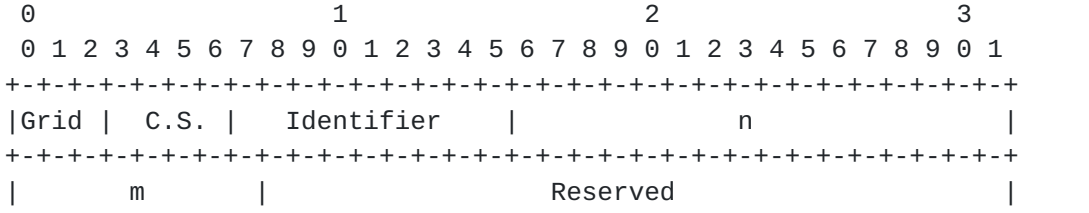


Figure 2 : Example Network

Node 1 receives the request for establishing an LSP from itself to Node 9. The ITU-T grid to be used is the Flexi-Grid, the channel spacing is 6.25 GHz, and the wavelength to be used is 193.05 THz. The cslot width to be used is 50 GHz. Node 1 signals the LSP using a Path message including a wavelength label structured as follows:



Where:

Grid = 3 : ITU-T Flexi-Grid

C.S. = 5 : 6.25 GHz channel spacing

Identifier = local value indicating the laser in use

n = 24 :

Frequency (THz) = 193.1 THz + n * channel spacing (THz)

193.05 (THz) = 193.1 (THz) + n* 0.00625 (THz)

n = (193.05-193.1)/0.00625 = -8

m = 4 :

Slot Width (GHz) = 12.5 GHz * m

50 (GHz) = 12.5 (GHz) * m

m = 50 / 12.5 = 4

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