Generalized Label for Super-Channel Assignment on Flexible Grid

draft-hussain-ccamp-super-channel-label-02

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Motivation

Fixed Grid Limitations

1. Future transport systems are expected to support data rates of 400 Gbps - 1 Tbps and beyond, using wider bandwidth optical channels
2. ITU-T G.694.1 (fixed-grid) permits allocation of channel spectrum bandwidth in "single" fixed- sized slots (e.g., 50GHz, 100GHz) independent of the channel bit rate.
3. This leads to inefficient use of optical spectrum due to excess frequency spacing for lower bit rate channels

Flexible Grid Benefits

- ❖ FlexGrid allows allocation of “arbitrary” size channel spectral bandwidth as an integer multiple of 12.5 GHz fine granularity contiguous or non-contiguous slices depending on required channel bit rate
- ❖ This enables supporting multiple data rate super-channels in a spectrally efficient manner

Super-Channel Label

Purpose

- A super-channel represents an ultra high aggregate capacity channel containing multiple carriers which are co-routed through the network as a single entity from the source transceiver to the sink transceiver
- This document defines a super-channel label format to setup an optical path manually or dynamically on a Flex-Grid network

Why?

- The existing label formats (e.g., RFC3471, RFC6205) either lack necessary fields to carry required flex-grid related information (e.g., channel spacing) or do not allow signaling of arbitrary flexible-size optical spectral bandwidth in an efficient manner (e.g., in terms of integer multiple of fine granularity slices)

Super-Channel Label Format

Label Definition

- This document defines a super-channel label as consisting of a Super-Channel Identifier and an associated list of slices representing the optical spectrum of the super-channel
- Optical spectrum of a super-channel is flexibly enabled to be any subset of the slices (allows for split-spectrum super-channels)
- The slice spacing used is identified within the label and can take on multiple standard options, with default flex-grid slice spacing of 12.5GHz used here

Label Encoding Options

- Option A: Encode super-channel label as a list of start and end slice numbers corresponding to N slots (where a slot is a contiguous set of optical spectrum slices) with each slot denoted by its starting and ending slice number (N defaults to 1 for use of a single slot super-channel)
- Option B: Encode super-channel label as a first slice number of the grid (denoted as "n_start of Grid") plus the entire list of slices in the grid as a Bitmap where '1' indicates inclusion of the slide in the super-channel

Super-Channel Label Encoding Option A

A logical identifier for a super-channel (similar to waveband Id defined in RFC3471)

Grid Type to be assigned by IANA (e.g., ITU-T Flex-Grid)

Slice Spacing (e.g., 12.5 GHz)

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Super-Channel Id (16-bit)  |Grid | S.S.  | Reserved (9-bit)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Reserved (16-bit)             |  Number of Entries(16-bit)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|n_start_1(contiguous slot  #1) | n_end_1(contiguous slot  #1)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|n_start_2(contiguous slot #2)  | n_end_2(contiguous   slot #2) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|n_start_N (contiguous slot #N) |   n_end_N (contiguous slot #N |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Number of 32-bit entries in the super-channel label , where each entry is a contiguous slot of optical spectrum

The lowest or starting slice number of the slot # 1

The highest or ending slice number of the slot #1

Super-Channel Label Encoding Option B

First slice number in optical Grid being referenced (i.e., the start of the left most edge of the Grid
For example n_start of Grid = -142 if the C-band left edge starts at 191.3250 THz using following formula:

```
Slice Left Edge Frequency (THz)= 193.1 THz + n*slice spacing (THz).

Where "n" is a two's-complement integer (i.e., positive, negative,
or 0) and "slice spacing" is 0.0125 THz conforming to ITU-T Flex-
Grid.
```

```
  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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Super-Channel Id (16-bit)    |Grid | S.S.   | Reserved (9-bit)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| n_start of Grid (16-bit)      |Num of Slices in Grid (16-bit) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Bitmap Word #1(first set of 32 slices from the left most edge) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Bitmap Word #2 (next set of 32 contiguous slice numbers)       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
                              ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Bitmap Word #N(last set of 32 contiguous slice numbers)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Total number of slices in the grid

Each bit in the 32-bitmap word represents a particular slice with a value of 1 or 0 to indicate whether for that slice reservation is required (1) or not (0). Bit position zero in the first word represents the first slice in the Grid and corresponds to the value indicated in the "n_start of Grid" field

Flexible Allowance of Split-Spectrum Super-Channel

Use Cases

- Avoid wasted bandwidth on fiber with fragmented BW due to super-channels with different spectral widths
  - Enable faster restoration of optical bandwidth in these scenarios
- Enable super-channel to efficiently use both sides around a non-viable part of spectrum (e.g., lambda zero)
- Enable assignment of a single super-channel label for a set of (e.g., alien) disjoint wavelengths that may be defined for use between a pair of ports

Super-Channel Label Example

- Assume the super-channel requires a spectral bandwidth of 200 GHz with left-edge frequency of 191.475 THz for the left-most 12.5 GHz slice and left-edge frequency of 191.6625 THz for the right-most slice
- n_start = (191.475 – 193.1)/0.0125 = -130 ← Slice Left Edge Frequency (THz) = 193.1 THz + n*slice spacing (THz)
- n_end = (191.6625 – 193.1)/0.0125 = -115

```
  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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Super-Channel Id (16-bit)    |Grid | S.S.  | Reserved (9-bit)|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Reserved (16-bit)             | Number of Entries(16-bit)     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|n_start_1 (contiguous slot #1)| n_end_1(contiguous slot #1)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where:

Super-Channel Id = 1 ; super-channel number 1

Number of Entries: 1

Grid = xx : ITU-T Flex-Grid

S.S. = 4 : 12.5 GHz Slice Spacing

n_start_1 = -130 : left-most 12.5 GHz slice number for slot 1

n_end_1 = -115 : Right-most 12.5 GHz slice number for slot 1

S.S. (GHz)	Value
Reserved	0
100	1
50	2
25	3
12.5	4
Future use	5 - 15

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Comparison of Flex-Grid Drafts

	draft-hussain-ccamp-super-channel-label-02	draft-farrkingel-ccamp-flexigrid-lambda-label-01	draft-zhang-ccamp-flexible-grid-rsvp-te-ext-00
Defines a new GMPLS label	**Yes**	**Yes**	**No**. Instead proposes to use RSVP Tspec to signal similar information
Encoding formats	Two options : Nx(start, end) and bitmap	Frequency (n) and spectrum width (m)	Frequency (n) and spectrum width (m)
Supports super-channels with contiguous spectrum	**Yes**	**Yes**	**Yes**
Supports split-spectrum super-channels	**Yes**	**No**	**No**
Flexibility to support networks with wavelength conversion	**Yes**	**Yes**	**No** **(Since Tspec is end-to-end)**