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Signaling extensions for Media Channel sub-carriers configuration in Spectrum Switched Optical Networks (SSON) in Lambda Switch Capable (LSC) Optical Line Systems.

draft-ggalimbe-ccamp-flexigrid-carrier-label-10

Abstract

This memo defines the signaling extensions for managing Spectrum Switched Optical Network (SSON) parameters shared between the Client and the Network and inside the Network in accordance to the model described in [RFC7698]. The extensions are in accordance and extending the parameters defined in ITU-T Recommendation G.694.1.[ITU.G694.1] and its extensions and G.872.[ITU.G872].

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1. Introduction

Generalized Multiprotocol Label Switching (GMPLS) is widely used in Wavelength Switched Optical Network (WSON) to support the optical circuit set-up through the signalling between Core Nodes and Edge Nodes (reusing terminology from [RFC4208. This extension addresses the use cases described by [RFC7698] Ch.3.3 and supports the information, needed in Spectrum Switched Optical Network (SSON), to signal a Media Channel and the associated carriers set request. The new set of parameters is related to the Media Channel and the carrier(s) routed with it and keep the backward compatibility with the WSON signalling. In particular this memo addresses the use cases where the SSON LSP (the Media Channel in RFC7698) use multiple

carrier (OTSi) to carry the Payload. The set of the carriers can be seen as single Logical circuit. This memo can be considered as the extension of [RFC7792].

Figure 1 shows how the multiple carrier are mapped into a Media Channel. A set of parameters must be shared on the UNI to allow the core control plane to do the proper routing and Spectrum Assignment and decide the carrier position.

```
   +------+       +------+  _________  +------+       +------+
   | E.N. |       | C.N. | /        /\ | C.N. |       | E.N. |
   |  OTS1| ----- |      ||        |  ||      | ----- |OTS1  |
 ==|  OTS2| ----- |      || Media  |  ||      | ----- |OTS2  |==
 ==|  OTS3| ----- |      || Channel|  ||      | ----- |OTS3  |==
   |  OTS4| ----- |      ||        |  ||      | ----- |OTS4  |
   |      |       | ROADM| \________\/ | ROADM|       |      |
   +------+       +------+             +------+       +------+
         ^         ^                         ^         ^
         |         |                         |         |
         +---UNI---+                         +---UNI---+
```

E.N. = Edge Node (a.k.a. UNI Client / transceiver shelf)
C.N. = Core Node (a.k.a. UNI Network / edge ROADM)
ROADM = Lambda/Spectrum switch
Media Channel = the optical circuit
OTSi = Carriers belonging to the same Network Media Channel (or
       Super Channel)
UNI = Signallig interface between E.N. and C.N.

Figure 1: Multi carrier LSP

2. Client interface parameters

The Edge Node interface can have one or multiple carriers (OTSi). All the carrier have the same characteristics and are provisionable in terms of:

Number of subcarriers:
This parameter indicates the number of subcarriers (OTSi) available for the super-channel (OTSiG) in case the Transceiver can support multiple carrier circuits. The OTSi is defined in ITU-T Recommendation G.959.1, section 3.2.4 [G.959.1]. The OTSiG is currently being moved from ITU-T Recommendation G.709 [G.709] to the new draft Recommendation G.807 (still work in progress) [G.807]. The OTSiG is an electrical signal that is carried by one

or more OTSi's. The relationship between the OTSiG and the OTSi's is described in ITU-T draft Recommendation G.807, section 10.2 [G.807]. This draft specifies the case where the each carrier (OTSi) is terminated on a physical port so the rtansceiver can have multiple ports. In future editions also the case where multiple carriers are terminated on the same port will be supported (also known as Sliceable Transponders).

Central frequency (see G.694.1 Table 1):
This parameter indicates the Central frequency value that Ss and Rs will be set to work (in THz). See the details in Section 6/ G.694.1 or based on "n" value explanation and the following "k" values definition in case of multicarrier transceivers.

Central frequency granularity:
This parameter indicates the Central frequency granularity supported by the transceiver, this value is combined with k and n value to calculate the central frequency of the carrier or sub-carriers.

Minimum channel spacing:
This is the minimum nominal difference in frequency (in GHz) between two adjacent channels (or carriers) depending on the Transceiver characteristics.

Bit rate / Baud rate of Optical Tributary Signals (OTSi):
Optical Tributary Signal bit (for NRZ signals) rate or Symbol (for Multiple bit per symbol) rate .

FEC Coding:
This parameter indicate what Forward Error Correction (FEC) code is used at Ss and Rs (R/W) (not mentioned in G.698.2). .

Wavelength Range (see G.694.1): [ITU.G694.1]
This parameter indicate minimum and maximum wavelength spectrum in a definite wavelength Band (L, C and S). That is the transceiver tunability range

Modulation format:
This parameter indicates the list of supported Modulation Formats and the provisioned Modulation Format.

Inter carrier skew:
This parameter indicates, in case of multi-carrier LSP (OTSiG) the maximum skew between the sub-carriers OTSi) supported by the transceivers.

Laser Output power:

This parameter provisions the Transceiver Output power, it can be either a setting and measured value.

Receiver input power:
This parameter provisions the Min and Max input power supported by the Transceiver, i.e. Receiver Sensitivity.

The above parameters are related to the Edge Node Transceiver and are used by the Core Network control plane in order to calculate the optical feasibility and the spectrum allocation. The parameters can be shared between the Client and the Network via LMP or provisioned to the Network by an EMS or an operator OSS.

3. Use Cases

The use cases are described in [RFC7698]

4. Signalling Extensions

The following sections specify the fields used in the RSVP-TE Path and Resv messages to address the requirements above. The above parameters could be applied to [RFC4208] scenarios but they are valid also in case of non UNI scenarios. The [RFC7699] parameters remain valid.

4.1. New LSP Request Parameters

When the E.N. wants to request to the C.N. a new circuit set-up, i.e. the control plane wants to signal in the SSON network the Optical Interface characteristics, the following parameters will be provided to the C.N.:

Number of available subcarriers (c):
This parameter is an integer and identifies the number of OTSi in an OTSiG. In this version of the document, it maps to the number of Client ports connected to the Core ports available to support the requested circuit.

Total bandwidth request:
e.g. 200Gb, 400Gb, 1Tb - it is the bandwidth (payload) to be carried by the multiple carrier circuit (OTSiG). In alternative the OTUCn can be used

Policy (strict/loose):
Strict/loose referred to B/W and subcarrier number. This is to give some flexibility to the GMPLS in order to commit client request.

Subcarrier bandwidth tunability:
(optional) e.g. 34Ghz, 48GHz.

The TLV define the resource constraints for the requested Media Channel.

The format of the sub-object is as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|S|B|     Reserved              |         Carrier Number        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Total Bandwidth                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: SSON LSP set-up request

Carrier Number: number of carrier to be allocated for the requested channel (16-bit unsigned integer)
If Carrier Number == 0 no constraint set on the number of carriers to be used

Total Bandwidth: the requested total bandwidth to be supported by the Media Channel (32-bit IEEE float, bytes/s)
If Total Bandwidth == 0: no bandwidth constraint is defined (B must be 0)

S strict number of subcarrier

- S = 0 the number of requested carriers is the maximum number that can be allocated (a lower value can be allocated if the requested bandwidth is satisfied)
- S = 1 the number of requested carriers is strict (must be > 0)

B Bandwidth constraints

- B = 0: the value is the maximum requested bandwidth (a lower value can be allocated if resources are not available)
- B = 1: the requested bandwidth is the minimum value to be allocated (a higher value can be allocated if requested by the physical constraints of the ports)

Reserved: unused bit (for future use, should be 0)

Note: bandwidth unit is defined in accordance to RFC 3471
chap. 3.1.2 Bandwith Encoding specification. Bandwidth higher
than 40Gb/s values must be defined (e.g. 100Gb/s, 150Gb/s
400Gb/s, etc.) or in alternative the OTUCn defined in
ITU-T G.709.

TLV Usage in RSVP-TE message:
Path from head E.N.: requested traffic constraints, the Head C.N.
must satisfy when reserving the optical resources and
defining the carriers configuration
The TLV can be omitted: no traffic constraints is defined
(resources allocated by C.N. based on a local policy)

4.2. Extension to LSP set-up specification

Once the WDM comtrol plane has calculated the Media Channel path, the Spectrum Allocation, the Sub-carrier number and frequency, the modulation format, the FEC and the Transmit power, it MUST send back to the E.N. the path set-up confirmation providing the values of the calculated parameters:

Media Channel:
(Grid, C.S., Identifier m and n). as indicated in RFC7699 Section 4.1

Modulation format:
This parameter indicates the Modulation Formats to be set in the Transceivers.

FEC Coding:
This parameter indicate what Forward Error Correction (FEC) code must be used by the Transceivers (not mentioned in G.698).   .

Baud rate of optical tributary signals:
Symbol (for Multiple bit per symbol) rate.

List of subcarriers:
This parameter indicates the subcarriers to be used for the super-channel (OTSiG) in case the Transceiver can support multiple carrier Circuits.

Central frequency granularity (J):
This parameter indicates the Central frequency granularity supported by the transceiver, this value is combined with K and n value to calculate the central frequency on the carrier or sub-carriers.

Central frequency (see G.694.1 Table 1):

Grid, Identifiers, central frequency and granularity.

Laser Output power:
This parameter provisions the Transceiver Output power, it can be either a setting and measured value.

Circuit Path, RRO, etc:
All these info are defined in [RFC4208].

Path Error:
e.g. no path exist, all the path error defined in [RFC4208].

4.2.1. Common Signal Description TLV

The TLV defines the carriers signal configuration.
All carriers in a Media Channel MUST have the same configuration.

It is aligned with TLV in 3.2.1 section in [I-D.draft-meuric-ccamp-tsvmode-signaling].

The format of this sub-object (Type = TBA, Length = TBA) is as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Modulation ID         |           Bit/Symbol          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              FEC              |       Min OSNR Threshold      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         baud rate  (Symbol Rate)              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: OCh_General

```
   Traffic Type
   - Modulation ID (Format) : is the modulation type:
         BPSK, DC DP BSPSK, QPSK, DP QPSK, 8QAM, 16QAM,
         32QAM, 64QAM, etc.
   - Bits/Symbol(BPS) this indicates the bit per symbol in case of
      hybrid modulation format. It is an off-set with values from 0
      to 127 to be applied to the specified Modulation Format and
      indicates the mix between the selected Modulation Format and its
      upper adjacent.
      (e.g. QPSK + 63 BPS indicates that there is a 50% MIX between
      QPSK and 8-QAM = 2.5 bits per symbol) If value = 0 the
      standard Modulation Format is applied
   - FEC: the signal Forward Error Corrections type (16-bit
            unsigned integer), the defined values are:
            - Value 0 is reserved to be used if no value is defined
   - Min OSNR Threshold: An integer specifying the minimum accepted
        threshold for the Optical Signal-Noise Ratio in 0.1 nm.
   - Baud Rate: the signal symbol rate (IEEE 32-bit float,
              in bauds/s)
            - Value 0 is reserved to be used if no value is defined

   Notes:
   - The Path message from the E.C. can specify all or
     only a subset of the parameters (e.g. the Modulation and the
     baud rate as required but not the FEC) setting to 0 for the
     undefined parameters.
     When forwarding the Path message, the C.N. will set the
     undefined parameters based on the optical impairment calculation
     and the constraints given by the E.N.
   - Custom codes (values > 0x8000) interpretation is a local
     installation matter.

   TLV Usage in RSVP-TE messages:
   - Path from the head E.N.: used to force specific transponder
     configurations
   - Path from the tail C.N.: set selected configuration on head node
   - Resv from the head C.N.: set selected configuration on tail node
```

4.2.2. Sub-carrier List Content TLV

For Each carrier inside the Media Channel the TLV is used.

The format of this sub-object (Type = TBA, Length = TBA) is as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Carrier Index          |               j               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               k                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            sub-TLVs                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Sub-Carrier parameters

Carrier setup:

- Carrier Index field: sub-carrier (OTSi) index
      inside the OTSiG (corresponding to the media channel).
      Identifies the carrier
      position inside the Media Channel (16-bit unsigned integer)
      The Carrier Index is the logical circuit sub-lane
      position, a TLV for each value from 1 to the number of
      allocated carriers must be present.
- J field: granularity of the channel spacing, can be a
      multiple of 0.01GHz. - default value is 0.1GHz.
- K field: positive or negative integer (including 0) to multiply
      by J and identify the Carrier Position inside the
      Media Channel, offset from media Channel Central frequency
- sub-TLVs: additional information related to carriers if needed
      and the ports associated to the carrier.

In summary Carrier Frequency = MC-C.F. (in THz) + K * J GHz.

```
                               m=8
 +-------------------------------X-------------------------------+
 |                               |                               |
 |           sub-carrier                     sub-carrier         |
 |     +----------X----------+   |   +----------X----------+     |
 |     |        OTSi         |       |        OTSi         |     |
 |     |          o          |   |   |          o          |     |
 |     |          |          |       |          |          |     |
-4   -3   -2   -1    0    1    2    3    4    5    6    7    8    9   10   11   12
-+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
                  |             n=4             |
                  K1     -236    |     +236     K2

 <------------------------ Media Channel ----------------------->
```

4.2.3. Sub-carrier sub-TLV

The defined sub-TLVs are Port Identifiers and Carrier Power

Source Port Identifier

The format of this sub-object (Type = TBA, Length = 8) is as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Type (TBA)         |    reserved   |   Length = 8  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Source Port Identifier                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Source Port Identifier

Source Port Identifier: the HEAD E.N. optical logical source end point identifier (32-bits integer, ifindex)

TLV Usage in RSVP-TE message:

- path from the head E.N.: used to force specific carrier ports [optional use, e.g. with external PCE scenario]
- Path from the tail C.N.: report selected carrier head ports to tail C.N.
- Resv: report selected configuration to head E.N.

Destination Port Identifier

The format of this sub-object (Type = TBA, Length = 8) is as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Type (TBA)         |   reserved    |   Length = 8  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Port Identifier                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Destination Port Identifiers

Destination Port Identifier: the local upstream optical logical destination end point identifier (32-bits integer, ifindex)

TLV Usage in RSVP-TE messages:

- Path from head E.N.: used to force specific carrier ports [optional use, e.g. with external PCE scenario]
- Path from tail C.N.: set selected configuration on tail node
- Resv: report selected configuration to the head E.N.

Carrier Power

The format of this sub-object (Type = TBA, Length = 8) is as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Type (TBA)         |  reserved     |   Length = 8  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          carrier power                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: Carrier Power

Carrier Power: the requested carrier transmit power (32-bits IEEE Float, dBm), optionally used to notify the configured power (from E.N. to C.N.) or force the power to from the C.N. to the E.N.

TLV Usage in RSVP-TE messages:

- Path from head the E.N.: used to force specific carrier frequency/ports (optional use, e.g. with external PCE scenario)
- Path from tail C.N.: set selected configuration on tail node
- Resv from the head C.N.: set selected configuration on head node

4.3. RSVP Protocol Extensions Considerations

The additional information described in the draft, is related to the Media Channel supported traffic. The parameters to be used by the egress transceivers are carried in Path messages. In RSVP-TE signaling, hop-specific information is encoded within the ERO as hop attributes and WDM parameters are to be carried as sub-TLVs within the Type 4 TLV [RFC7689], in the Hop Attributes SubObject

Beside, some of the additional information defined is local to the head/tail UNI link (e.g. the carrier/port association), while the traffic spec info should be valid end-to-end.

There can be different methods to model and signal the carriers as described in draft-ietf-ccamp-optical-impairment-topology-yang. The Media Channel, Network Media Channel and lables are well modelled by the RFC7698, RFC7699 and RFC7792 reflecting the ITU-T Recommendations G.694.1 and G.698.2.

Some work is in progress in ITU-T SG15/Q12 to define Network Media Channel (group) that is capable of accommodating the optical tributary signals (OTSi) belonging to optical tributary signal group (OTSiG) (see new ITU-T Draft Recommendation G.807).

Other the encoding proposal reported in this draft, there are several at least two other methods to describe the parameters. An option is to describe the OTSi carrier frequency relative to the anchor frequency 193.1THz based on a well-defined granularity (e.g. OTSi carrier frequency = 193100 (GHz) + K * granularity (GHz) where K is a signed integer value). A second option is to explicitly describe the OTSi carrier frequency and the OTSi signal width in GHz with a certain accuracy.

The second option which is independent of the n, m values already defined in ITU-T Recommendation G.694.1. The OTSi carrier frequency is described in GHz with 3 fractional digits (decimal 64 fraction digits 3). The OTSi signal width is described in GHz with 3 fractional digits (decimal 64 fraction digits 3) and includes the signal roll off as well as some guard band.

The accuracy of 0.001 GHz does not impose a requirement on the optical transceiver components (optical transmitter) in terms of carrier frequency tunability precision. Today's components typically provide a tunability precision in the range of 1..1.5GHz (carrier frequency offset compared to the configured nominal carrier frequency).
Future components may provide a better precision as technology evolves. If needed, a controller may retrieve the transceiver properties in terms of carrier frequency tunability precision in order to be capable of properly configuring the underlying transceiver.

NOTE FROM THE EDITORS: As this description is arbitrarily proposed by the authors to cover a lack of information in IETF and ITU-T, a liaison request to ITU-T is needed. The authors are willing to contribute to Liaison editing and to consider any feedback and proposal from ITU-T.

5. Security Considerations

RSVP-TE message security is described in [RFC5920]. IPsec and HMAC-MD5 authentication are common examples of existing mechanisms. This document only defines new UNI objects that are carried in existing UNI messages, thus it does not introduce new security considerations.

6. IANA Considerations

The IANA is requested to create, within the "GMPLS Signaling Parameters" registry, two new sub-registries named "WDM Modulation Formats" and "WDM FEC Types".

For both of them:

- o the value 0 means "Pending selection",
- o the range 1-65503 follows the Expert Review policy for registration,
- o the range 65504-65535 is for experimental use.

The "WDM Modulation Format" sub-registry is initialized as follows:

Value	Modulation Format
0	Pending selection
1	DPSK
2	QPSK
3	8-QAM
4	16-QAM
5	32-QAM
6	64-QAM
7-63999	Unallocated
64000-65535	Vendor specific use

The "WDM FEC Types" sub-registry is initialized as follows:

Value	FEC Types
0	Pending selection
1	Reed Solomon FEC
2	Staircase FEC
3	O-FEC.
4-63999	Unallocated
64000-65535	Vendor specific use

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