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          TE extensions to OSPF for GMPLS control of Flex-Grid Networks
                 draft-dhillon-ccamp-flexgrid-ospfte-ext-00.txt

Abstract

   This document specifies the extension to TELINK LSA of OSPF routing
   protocol [RFC4203] [3] in support of GMPLS [1] for flex-grid
   networks [2].

   This draft is a renamed version of ''draft-dhillon-ccamp-super-
   channel-ospfte-ext-06.txt'' [11]. To align with ITU terminology,
   references to super-channel have been removed in the title & other
   parts of the document.

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   1. Introduction

To enable scaling of existing transport systems to ultra-high data
rates of 1 Tbps and beyond, next generation systems providing ultra-
high capacity optical switching capability are currently being
developed. To allow efficient allocation of optical spectral
bandwidth for such high bit rate systems, International
Telecommunication Union Telecommunication Standardization Sector

(ITU-T) is extending the G.694.1 grid standard (termed ''Fixed-Grid'')
to include flexible grid (termed ''Flex-Grid'') support [10].

This document defines OSPF-TE extensions in support of flex-grid
networks.

Figure-1 shows a network capable of switching in Flexible-Grid[10].
The physical media/Fiber is modeled as a TE-Link to advertise
spectrum (bandwidth) availability. This information is used during
Flex-grid LSP[10] creation([2]). This draft defines extensions to
ISCD in support of Flexible-Grid.

```
     +-------+                +-------+              +-------+
     | SC    |                | SC    |              | SC    |
     |Switch |<---Link --->   |Switch |<- Link----- ->|Switch |
     | A     |                | B     |              | C     |
     +-------+                +-------+              +-------+

        |<-- TE-Link -->|        |<-- TE-Link -->|
```
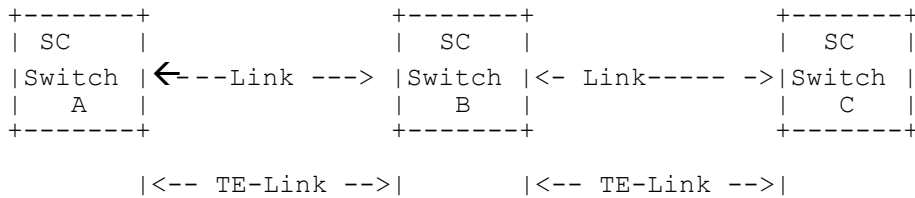
Figure 1: TE-Links

2. Terminology

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].

3. Interface Switching Capability Descriptor

The Interface Switching Capability Descriptor describes switching
capability of an interface [RFC 4203]. This document defines a new
Switching Capability value for Flex Grid [FLEX-GRID] as follows:

```
Value                         Type
-----                         ----
102 (TBA by IANA)    Spectrum-Switch-Capable (SSC)
```

Switching Capability and Encoding values MUST be used as follows:

        Switching Capability = SSC

Encoding Type = Lambda [as defined in RFC3471]

The Interface Switching Capability Descriptor is a sub-TLV (of type
15) of the Link TLV. The length is the length of value field in
Octets. The format of the value field is as shown below:


```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Switching Cap |   Encoding    |             Reserved          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 0                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 1                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 2                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 3                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 4                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 5                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 6                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Max LSP Bandwidth at priority 7                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Switching Capability-specific information            |
|                        (variable)                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: ISCD & SCSI

Max LSP Bandwidth will be based on Max Slot Width field in BW-sub-TLV
(Ref to section 3.1 for details on BW sub-TLV) and the modulation
format used.

3.1. Switch Capability Specific Information

The technology specific part of the ISCD can include a variable number
of sub-TLVs. We propose to encode Slice Information in Bandwidth sub-
TLVs under SCSI field. The format of BW sub-TLVs is as shown below.

[Editor's note: To provide options similar to Label set field defined
in [9], we have included 2 variants to advertise slice level
information. These are bit-format and list/range format].

3.2. BW sub TLV: Bit Map format

The figure below shows format of Type=1 sub-TLV for encoding slice
information in bit-map format. This sub-TLV must be repeated for each
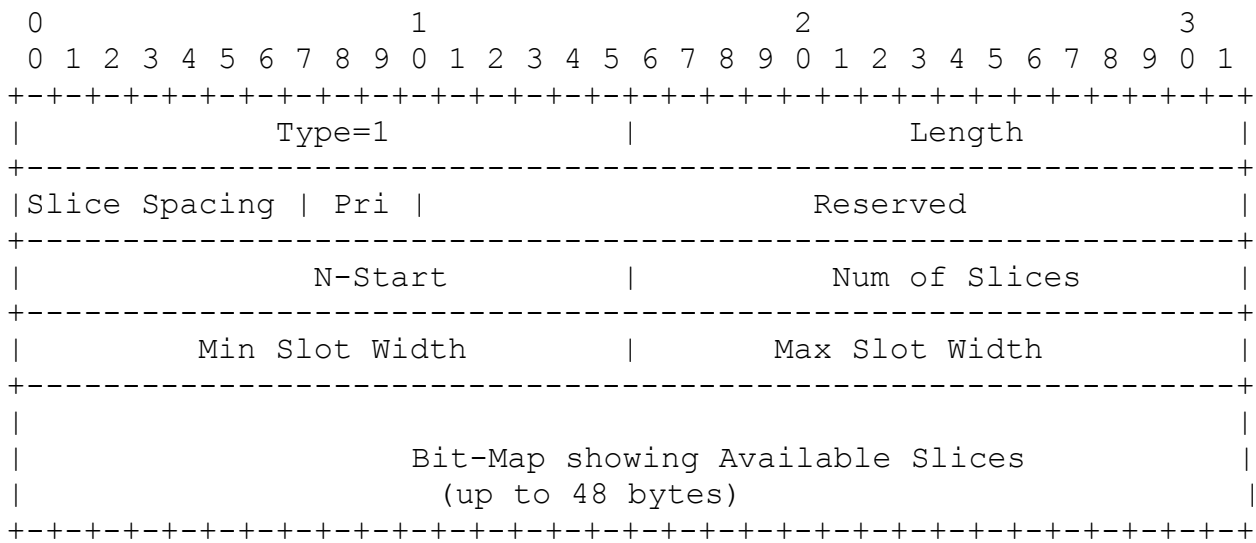priority that is supported on the Te-link.

```
    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=1             |             Length            |
   +---------------------------------------------------------------+
   |Slice Spacing | Pri |                Reserved                  |
   +---------------------------------------------------------------+
   |            N-Start           |         Num of Slices          |
   +---------------------------------------------------------------+
   |        Min Slot Width        |         Max Slot Width         |
   +---------------------------------------------------------------+
   |                                                               |
   |             Bit-Map showing Available Slices                  |
   |                    (up to 48 bytes)                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

           Figure 3: Type=1 BW sub TLV in Bit-Map format

3.2.1. Meaning of sub TLV fields

   o Slice Spacing: 8-bit field (S.S) which can take one of the values
      as shown in table below.
        o For e.g., the 12.5GHz spacing is specified by setting this
           field to value 4.

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

               Table 1: Slice Spacing Values

o Priority: 3-bit field
     o 3-bit field to identify one of the 8 priorities for which
       Slice information (BW) is advertised.
o N-Start: 16-bit field
     o Is a two's complement integer to specify start of the grid
     o Use center freq formula to determine start of spectrum
o Number of slices: 16-bit field
     o Total number of slices advertised for the link. This includes
       (available plus consumed).
o Minimum Slot Width: 16-bit field
     o This is a positive integer value
     o This field is similar to Min LSP BW field. The value in this
       field is used to determine the smallest frequency slot width
       that the advertising node can allocate for an LSP.   This is
       defined by the following equation:
       Smallest Frequency slot width = Slice Spacing * integer value
       in 'Minimum Slot Width' field
o Maximum Slot Width: 16-bit field
     o This is a positive integer value
     o This field is used to determine the Maximum contiguous
       frequency slot width that the advertising node can allocate
       for an LSP.   This is defined by the following equation:
       Largest Contiguous Frequency slot width = Slice Spacing *
       integer value in 'Maximum Slot Width' field
o Available slices encoded as bit-map
     o Each bit represents availability of one slice of width
       identified by S.S field
     o Zero: Available ; One: occupied
     o Padding MUST be used to align with 32 bit boundary.

3.3. BW sub TLV: List and Rage format

The figure below shows format of Type=2 sub-TLV for encoding slice information in list/range format. This sub-TLV must be repeated for each priority that is supported on the Te-Link.
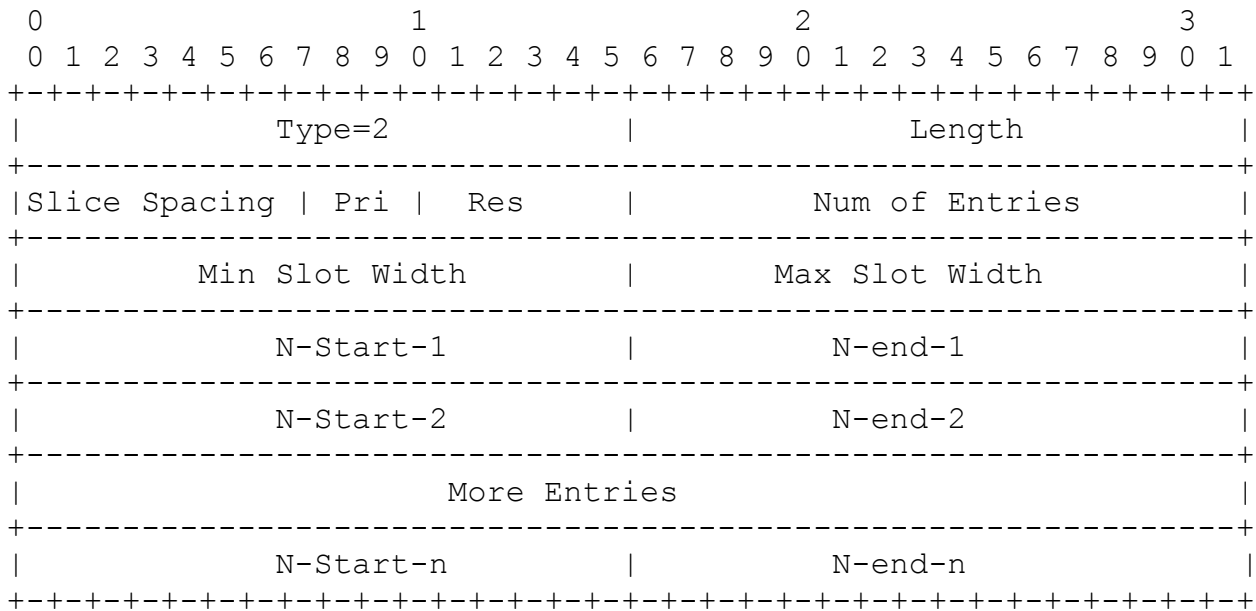
```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |              Type=2            |              Length           |
   +---------------------------------------------------------------+
   |Slice Spacing | Pri |  Res      |        Num of Entries         |
   +---------------------------------------------------------------+
   |         Min Slot Width         |         Max Slot Width        |
   +---------------------------------------------------------------+
   |            N-Start-1           |             N-end-1           |
   +---------------------------------------------------------------+
   |            N-Start-2           |             N-end-2           |
   +---------------------------------------------------------------+
   |                         More Entries                          |
   +---------------------------------------------------------------+
   |            N-Start-n           |             N-end-n           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Type=2 BW sub TLV in List/Range format

3.3.1. Meaning of sub TLV fields

   o The meaning of above fields is same as in Type=1 BW-sub-TLV. For
      details refer to section 3.2.1.
         o Slice Spacing,
         o Priority,
         o Maximum Slot Width &
         o Minimum Slot Width
   o Number of Entries: 16-bit field
         o Is a positive integer value.
         o Total number of N-start & N-End rows advertised for the link.
   o N-Start-x: 16-bit field
         o Is a two's complement integer value (+ve, -ve or zero) to
            specify start of the grid.

o Use center freq formula to determine start of spectrum

   o N-end-x: 16-bit field
        o Is a two's complement integer value (+ve, -ve or zero)to
           specify end of the list/range.
        o Use center freq formula to determine end of spectrum

3.4. BW advertisement procedure

   This section describes bandwidth advertisement for Te-Links capable
   SSC.

   o Optical nodes capable of Spectrum Switching advertise slices of
      certain width available based on the frequency spectrum supported
      by the node (e.g. C band, extended C-band). For example, node(s)
      supporting extended C-band will advertise 384 slices.
   o The BW advertisement involves an ISCD containing
        o Slice information in bit-map format (Type=1 BW-sub-TLV) where
           each bit corresponds to a single slice of width as identified
           by S.S field.   OR
        o Slice information in list/range format (Type=2 BW-sub-TLV)
           where each 32-bit entry represents an individual slice or
           list or range.
   o The slice position/numbering in Type=1 sub-TLV is identified based
      on N-start field. The N-start field is derived based on ITU
      center frequency formula.
   o The advertising node MUST also set Number of Slices field.
   o Minimum & Maximum slot width fields are included to allow for any
      restrictions on the link for carrying Flex Grid LSPs.
   o The BW advertisement is priority based and up to 8 priority levels
      are allowed.
   o The node capable of supporting one or more priorities MUST set the
      priority field and include BW-sub TLV for each of the priority
      supported.

     4. Examples

4.1. Example: BW advertisement without any service present

   Figure 5 shows an example of BW sub-TLV for a te-link which has no
   service established over it yet. Attributes of BW sub-TLV in the te-
   link are:

    o N-start=-142 for extended C-band (2's complement should be
      included in this field)
    o Total number of slices available on the link = 384 (based on
      Slice spacing = 12.5GHz)
    o Min SW field shows min consumption of 4 Slices per LSP
      (=50GHz)
    o Max SW field shows up to 400GHz BW allowed per LSP (32x12.5GHz)
    o 48 bytes showing that all 384 slices are available.


```
 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=1            |             Length              |
+-------------------------------------------------------------+
|S.S = 4(12.5) | Pri |                Reserved                 |
+-------------------------------------------------------------+
|            N-Start=-142     |        Num of Slices=384        |
+-------------------------------------------------------------+
|       Min Slot Width=4      |        Max Slot Width=32        |
+-------------------------------------------------------------+
|                                                             |
|            Bit-Map showing info for 384 slice               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
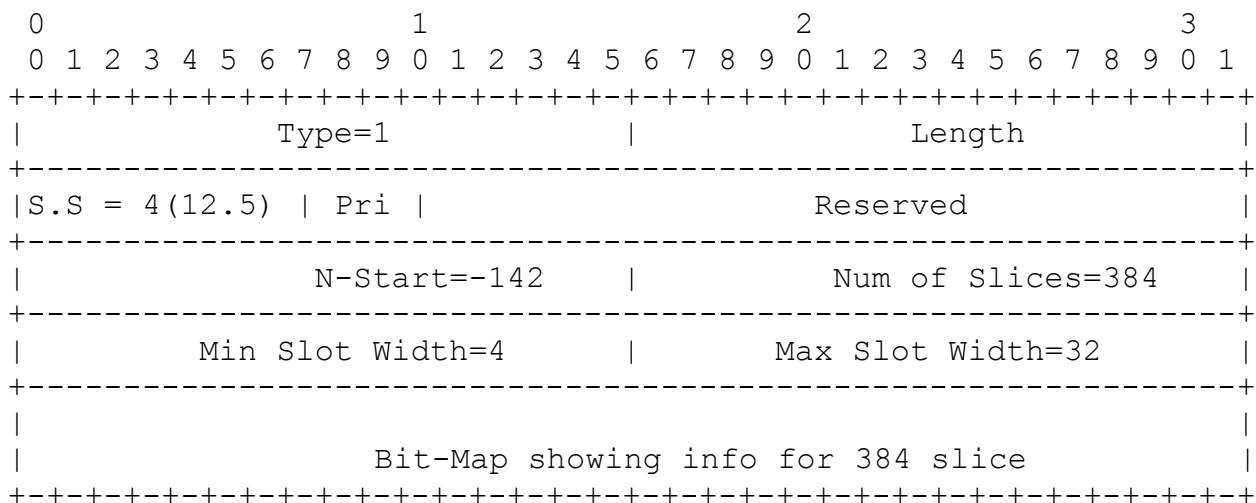
           Figure 5: Type=1 BW sub-TLV without any service present

4.2. Example: How to use advertise Bandwidth

   Assume user wants to setup Flex Grid LSP over a single Flex-Grid link
   with BW requirement = 200GHz and transponder fully tunable.

   o The path computing node performs the following:
        o Determine the number of slices required for the LSP (200/S.S =
          16)
        o Look for contiguous spectrum availability on each link from BW
          advertisement (both dir)
        o Look for 16 contiguous bits in the BW advertisement TLV
        o If available select the link for LSP creation.
        o Signal for LSP creation. Once LSP is created, update BW
          available via new advertisement using the same Bandwidth sub-
          TLV.

5. Security Considerations

<Add any security considerations>

6. IANA Considerations

IANA needs to assign a new Grid field value to represent ITU-T Flex-Grid.

7. References

7.1. Normative References

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

7.2. Informative References

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       Spectral Efficiency Transmission '',in Proc. ECOC 2010, paper
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[8]   Oscar G, et al., ``Framework and Requirements for GMPLS based
        control of Flexi-grid DWDM networks'', draft-ietf-ccamp-flexi-
        grid-fwk-00, work in progress.

[9]   G. Bernstein, Y. Lee, D. Li, W. Imajuku, " General Network
        Element Constraint Encoding for GMPLS Controlled Networks",
        work in progress: draft-ietf-ccamp-general-constraint-encode-
        05, May 2011

[10]   [FLEX-GRID] "ITU-T Recommendation G.694.1, Spectral grids for
        WDM applications: DWDM frequency grid", November 2012.

[11]   Previous version of this draft: OSPFTE extension to support
        GMPLS for Flex Grid: draft-dhillon-ccamp-super-channel-
        ospfte-ext-06.txt

8. Acknowledgments

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