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Routing and Wavelength Assignment Information Encoding for Wavelength Switched Optical Networks

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Abstract

A wavelength switched optical network (WSON) requires that certain key information elements are made available to facilitate path computation and the establishment of label switching paths (LSPs). The information model described in "Routing and Wavelength Assignment Information for Wavelength Switched Optical Networks" shows what information is required at specific points in the WSON. Part of the WSON information model contains aspects that may be of general applicability to other technologies, while other parts are fairly specific to WSONs.

This document provides efficient, protocol-agnostic encodings for the WSON specific information elements. It is intended that protocol-specific documents will reference this memo to describe how information is carried for specific uses. Such encodings can be used to extend GMPLS signaling and routing protocols. In addition these encodings could be used by other mechanisms to convey this same information to a path computation element (PCE).

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].

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1. Introduction

A Wavelength Switched Optical Network (WSON) is a Wavelength Division Multiplexing (WDM) optical network in which switching is performed selectively based on the center wavelength of an optical signal.

[RFC6163] describes a framework for Generalized Multiprotocol Label Switching (GMPLS) and Path Computation Element (PCE) control of a WSON. Based on this framework, [WSON-Info] describes an information model that specifies what information is needed at various points in a WSON in order to compute paths and establish Label Switched Paths (LSPs).

This document provides efficient encodings of information needed by the routing and wavelength assignment (RWA) process in a WSON. Such encodings can be used to extend GMPLS signaling and routing protocols. In addition these encodings could be used by other mechanisms to convey this same information to a path computation element (PCE). Note that since these encodings are relatively efficient they can provide more accurate analysis of the control plane communications/processing load for WSONs looking to utilize a GMPLS control plane.

Note that encodings of information needed by the routing and label assignment process applicable to general networks beyond WSON are addressed in a separate document [Gen-Encode]. This document makes use of the Label Set Field encoding of [Gen-Encode] and refers to it as a Wavelength Set Field.

1.1. Revision History

1.1.1. Changes from 00 draft

Edits to make consistent with update to [RFC6205], i.e., removal of sign bit.

Clarification of TBD on connection matrix type and possibly numbering.

New sections for wavelength converter pool encoding: Wavelength Converter Set Sub-TLV, Wavelength Converter Accessibility Sub-TLV, Wavelength Conversion Range Sub-TLV, WC Usage State Sub-TLV.

Added optional wavelength converter pool TLVs to the composite node TLV.

1.1.2. Changes from 01 draft

The encoding examples have been moved to an appendix. Classified and corrected information elements as either reusable fields or sub-TLVs. Updated Port Wavelength Restriction sub-TLV. Added available wavelength and shared backup wavelength sub-TLVs. Changed the title and scope of section 6 to recommendations since the higher level TLVs that this encoding will be used in is somewhat protocol specific.

1.1.3. Changes from 02 draft

Removed inconsistent text concerning link local identifiers and the link set field.

Added E bit to the Wavelength Converter Set Field.

Added bidirectional connectivity matrix example. Added simple link set example. Edited examples for consistency.

1.1.4. Changes from 03 draft

Removed encodings for general concepts to [Gen-Encode].

Added in WSON signal compatibility and processing capability information encoding.

1.1.5. Changes from 04 draft

Added encodings to deal with access to resource blocks via shared fiber.

1.1.6. Changes from 05 draft

Revised the encoding for the "shared access" indicators to only use one bit each for input and output.

1.1.7. Changes from 06 draft

Removed section on "WSON Encoding Usage Recommendations"

1.1.8. Changes from 07 draft

Section 3: Enhanced text to clarify relationship between pools, blocks and resources. Section 3.1, 3.2: Change title to clarify Pool-Block relationship. Section 3.3: clarify block-resource state.

Section 4: Deleted reference to previously removed RBNF element. Fixed TLV figures and descriptions for consistent sub-sub-TLV nomenclature.

1.1.9. Changes from 08 draft

Fixed ordering of fields in second half of sub-TLV example in Appendix A.1.

Clarifying edits in section 3 on pools, blocks, and resources.

1.1.10. Changes from 09 draft

Fixed the "Block Shared Access Wavelength Availability sub-TLV" of section 3.4 to use an "RB set field" rather than a single RB ID. Removed all 1st person idioms.

1.1.11. Changes from 10 draft

Removed remaining 1st person idioms. Updated IANA section. Update references for newly issued RFCs.

1.1.12. Changes from 11 draft

Fixed length fields in section 4 to be 16 bits, correcting errors in TLV and field figures. Added a separate section on resources, blocks, sets and the resource pool. Moved definition of the resource block set field to this new section.

1.1.13. Changes from 12 draft

Replaced all instances of "ingress" with "input" and all instances of "egress" with "output".

1.1.14. Changes from 13 draft

C bit of Resource Block Set Field is redundant and was removed, i.e., has been returned to "Reserved" block and appendix examples were updated to reflect the change.

Enhanced section 4.2 encoding to allow for optionality of input or output wavelength set fields.

Clarified that wavelength set fields use the Label Set field encoding from [Gen-Encode].

Enhanced section 5.1 encoding to simplify the Modulation and FEC input and output cases.

1.1.15. Changes from 14 draft

OIC changes per workgroup request. Removed FEC type and modulation type. Fixed versioning error and return RB identifiers to 32 bits.

1.1.16. Changes from 15 draft

Edits of OIC related text per CCAMP list email.

1.1.17. Changes from 16 draft

Added full ITU-T string to 64 bit mapping to text from OIC draft.

1.1.18. Changes from 17 draft

Action value for Inclusive Range(s) changed to 1 from 2 for the Resource Block Set Field encoding in Section 3.1.

Added a list of contributors who provided texts for the Optical Interface Class (OIC) description.

1.1.19. Changes from 18 draft

Added Section 5.2.5 to include ITU-G.695 Application Code Mapping.

2. Terminology

CWDM: Coarse Wavelength Division Multiplexing.

DWDM: Dense Wavelength Division Multiplexing.

FOADM: Fixed Optical Add/Drop Multiplexer.

ROADM: Reconfigurable Optical Add/Drop Multiplexer. A reduced port count wavelength selective switching element featuring input and output line side ports as well as add/drop side ports.

RWA: Routing and Wavelength Assignment.

Wavelength Conversion. The process of converting an information bearing optical signal centered at a given wavelength to one with "equivalent" content centered at a different wavelength. Wavelength conversion can be implemented via an optical-electronic-optical (OEO) process or via a strictly optical process.

WDM: Wavelength Division Multiplexing.

Wavelength Switched Optical Network (WSON): A WDM based optical network in which switching is performed selectively based on the center wavelength of an optical signal.

3. Resources, Blocks, Sets, and the Resource Pool

The optical system to be encoded may contain a pool of resources of different types and properties for processing optical signals. For the purposes here a "resource" is an individual entity such as a wavelength converter or regenerator within the optical node that acts on an individual wavelength signal.

Since resources tend to be packaged together in blocks of similar devices, e.g., on line cards or other types of modules, the fundamental unit of identifiable resource in this document is the "resource block". A resource block may contain one or more resources. As resource blocks are the smallest identifiable unit of processing resource, one should group together resources into blocks if they have similar characteristics relevant to the optical system being modeled, e.g., processing properties, accessibility, etc.

This document defines the following sub-TLVs pertaining to resources within an optical node:

Resource Pool Accessibility Sub-TLV

Resource Block Wavelength Constraints Sub-TLV

Resource Pool State Sub-TLV

Block Shared Access Wavelength Availability Sub-TLV

Resource Block Information Sub-TLV

Each of these sub-TLVs works with one or more sets of resources rather than just a single resource block. This motivates the following field definition.

3.1. Resource Block Set Field

In a WSON node that includes resource blocks (RB), denoting subsets of these blocks allows one to efficiently describe common properties of the blocks and to describe the structure and characteristics, if non-trivial, of the resource pool. The RB Set field is defined in a similar manner to the label set concept of [RFC3471].

The information carried in a RB set field is defined by:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Action     |C|  Reserved   |         Length                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        RB Identifier 1                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                               :                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         RB Identifier n                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Action: 8 bits

0 - Inclusive List

Indicates that the TLV contains one or more RB elements that are included in the list.

1 - Inclusive Range(s)

Indicates that the TLV contains one or more ranges of RBs. Each individual range is denoted by two 32 bit RB identifier. The first

32 bits is the RB identifier for the start of the range and the next 32 bits is the RB identifier for the end of the range. Note that the Length field is used to determine the number of ranges.

C (Connectivity bit): Set to 0 to denote fixed (possibly multi-cast) connectivity; Set to 1 to denote potential (switched) connectivity. Used in resource pool accessibility sub-TLV. Ignored elsewhere.

Reserved: 7 bits

This field is reserved. It MUST be set to zero on transmission and MUST be ignored on receipt.

Length: 16 bits

The total length of this field in bytes.

RB Identifier:

The RB identifier represents the ID of the resource block which is a 32 bit integer.

Usage Note: the inclusive range "Action" can result in very compact encoding of resource sets and it can be advantages to number resource blocks in such a way so that status updates (dynamic information) can take advantage of this efficiency.

4. Resource Pool Accessibility/Availability

This section defines the sub-TLVs for dealing with accessibility and availability of resource blocks within a pool of resources. These include the ResourceBlockAccessibility, ResourceWaveConstraints, and RBPoolState sub-TLVs.

4.1. Resource Pool Accessibility Sub-TLV

This sub-TLV describes the structure of the resource pool in relation to the switching device. In particular it indicates the ability of an input port to reach sets of resources and of a sets of resources to reach a particular output port. This is the PoolInputMatrix and PoolOutputMatrix of [WSON-Info].

The resource pool accessibility sub-TLV is defined by:

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Connectivity  |                     Reserved                  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                  Input Link Set Field A #1                    |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                        RB Set Field A #1                      |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Additional Link set and RB set pairs as needed to      |
    :                  specify PoolInputMatrix                    :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                Output Link Set Field B #1                     |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |             RB Set B Field #1 (for output connectivity)       |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        Additional Link Set and RB set pairs as needed to      |
    :                  specify PoolOutputMatrix                     :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where

Connectivity indicates how the input/output ports connect to the resource blocks.

0 -- the device is fixed (e.g., a connected port must go through the resource block)

1 -- the device is switched (e.g., a port can be configured to go through a resource but isn't required)

The For the Input and Output Link Set Fields, the Link Set Field encoding defined in [Gen-Encode] is to be used.

Note that the direction parameter within the Link Set Field is used to indicate whether the link set is an input or output link set, and the bidirectional value for this parameter is not permitted in this sub-TLV.

See Appendix A.1 for an illustration of this encoding.

4.2. Resource Block Wavelength Constraints Sub-TLV

Resources, such as wavelength converters, etc., may have a limited input or output wavelength ranges. Additionally, due to the structure of the optical system not all wavelengths can necessarily reach or leave all the resources. These properties are described by using one or more resource wavelength restrictions sub-TLVs as defined 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|I|O|B|                      Reserved                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      RB Set Field                             |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Input Wavelength Set Field                    |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Output Wavelength Set Field                   |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

I = 1 or 0 indicates the presence or absence of the Input Wavelength Set Field.

O = 1 or 0 indicates the presence or absence of the Output Wavelength Set Field.

B = 1 indicates that a single wavelength set field represents both input and output wavelength constraints.

Currently the only valid combinations of (I,O,B) are (1,0,0), (0,1,0), (1,1,0), (0,0,1).

RB Set Field:

A set of resource blocks (RBs) which have the same wavelength restrictions.

Input Wavelength Set Field:

Indicates the wavelength input restrictions of the RBs in the corresponding RB set. This field is encoded via the Label Set field of [Gen-Encode].

Output Wavelength Set Field:

Indicates the wavelength output restrictions of RBs in the corresponding RB set. This field is encoded via the Label Set field of [Gen-Encode].

4.3. Resource Pool State Sub-TLV

The state of the pool is given by the number of resources available with particular characteristics. A resource block set is used to encode all or a subset of the resources of interest. The usage state of resources within a resource block set is encoded as either a list of 16 bit integer values or a bit map indicating whether a single resource is available or in use. The bit map encoding is appropriate when resource blocks consist of a single resource. This information can be relatively dynamic, i.e., can change when a connection (LSP is established or torn down.

```
 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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | Action        |    Reserved                                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                     RB Set Field                              |
 :                                                               :
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                  RB Usage state                               |
 :                                                               :
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where Action = 0 denotes a list of 16 bit integers and Action = 1 denotes a bit map. In both cases the elements of the RB Set field are in a one-to-one correspondence with the values in the usage RB usage state area.

```
  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | Action = 0    |    Reserved                                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                     RB Set Field                              |
 :                                                               :
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                  RB#1 state   |      RB#2 state               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 :                                                               :
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                 RB#n-1 state  |   RB#n state or Padding       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Whether the last 16 bits is a wavelength converter (RB) state or padding is determined by the number of elements in the RB set field.

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Action = 1    |    Reserved                                   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                     RB Set Field                              |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                  RB Usage state bitmap                        |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                     ......            |      Padding bits     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

RB Usage state: Variable Length but must be a multiple of 4 byes.

Each bit indicates the usage status of one RB with 0 indicating the RB is available and 1 indicating the RB is in used. The sequence of the bit map is ordered according to the RB Set field with this sub-TLV.

Padding bits: Variable Length

4.4. Block Shared Access Wavelength Availability sub-TLV

Resources blocks may be accessed via a shared fiber. If this is the case, then wavelength availability on these shared fibers is needed to understand resource availability.

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |I|E|                         Reserved                          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                     RB Set Field                              |
    :                                                               :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |            Input Available Wavelength Set Field               |
    :                          (Optional)                           :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |             Output Available Wavelength Set Field             |
    :                          (Optional)                           :
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

I bit:

Indicates whether the input available wavelength set field is included (1) or not (0).

E bit:

Indicates whether the output available wavelength set field is included (1) or not (0).

RB Set Field:

A Resource Block set in which all the members share the same input or output fiber or both.

Input Available Wavelength Set Field:

Indicates the wavelengths currently available (not being used) on the input fiber to this resource block. This field is encoded via the Label Set field of [Gen-Encode].

Output Available Wavelength Set Field:

Indicates the wavelengths currently available (not being used) on the output fiber from this resource block. This field is encoded via the Label Set field of [Gen-Encode].

5. Resource Properties Encoding

Within a WSON network element (NE) there may be resources with signal compatibility constraints. These resources be regenerators, wavelength converters, etc... Such resources may also constitute the network element as a whole as in the case of an electro optical switch. This section primarily focuses on the signal compatibility and processing properties of such a resource block.

The fundamental properties of a resource block, such as a regenerator or wavelength converter, are:

(a) Input constraints (shared input, modulation, FEC, bit rate, GPID)

(b) Processing capabilities (number of resources in a block, regeneration, performance monitoring, vendor specific)

(c) Output Constraints (shared output, modulation, FEC)

5.1. Resource Block Information Sub-TLV

Resource Block descriptor sub-TLVs are used to convey relatively static information about individual resource blocks including the resource block compatibility properties, processing properties, and the number of resources in a block.

This sub-TLV has the following format:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     RB Set Field                              |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|I|E|                           Reserved                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Optical Interface Class List(s) Sub-Sub-TLV  (opt)      |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Input Client Signal Type Sub-Sub-TLV      (opt)       |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Input Bit Rate Range List  Sub-Sub-TLV (opt)          |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Processing Capabilities List Sub-Sub-TLV (opt)        |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where I and E, the shared input/output indicator, is set to 1 if the resource blocks identified in the RB set field utilized a shared fiber for input/output access and set to 0 otherwise.

5.2. Optical Interface Class List(s) Sub-Sub-TLV

The list of Optical Interface Class sub-sub-TLV has the following format:

```
  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    |    Length     |       Reserved            |I|E|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |       Optical Interface Classes                               |
 :                                                               :
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The following I and E combination are defined:

I   E

0   0   Invalid

1   0   Optical Interface Class List acceptable in input

0   1   Optical Interface Class List available in output

1   1   Optical Interface Class List available on both input and output.

The Resource Block MAY contain one or more lists according to input/output flags.

5.2.1. Optical Interface Class Format

```
 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|     Reserved                |    OI Code Points             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |         Optical Interface Class                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |         Optical Interface Class  (Cont.)                      |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where the first 32 bits of the encoding shall be used to identify the semantic of the Optical Interface Class in the following way:

S Standard bit.

S=0, identify not ITU code points

S=1, identify ITU application codes

With S=0, the OI Code Points field can take the following values:

0: reserved

1: Vendor Specific Optical Interface Class.

With S=1, the OI Code Points field can take the following values:

0: reserved

1: [ITU-G.698.1] application code.

2: [ITU-G.698.2] application code.

3: [ITU-G.959.1] application code.

4: [ITU-G.695.1] application code.

In case of ITU Application Code, the mapping between the string defining the application code and the 64 bits number implementing the optical interface class is given in the following sections.

5.2.2. ITU-G.698.1 Application Code Mapping

Recommendation ITU-G.698.1 defines the Application Codes: DScW-ytz(v) and B-DScW-ytz(v). Where:

B: means Bidirectionals.

D: means a DWDM application.

S: take values N (narrow spectral excursion), W (wide spectral excursion).

c: Channel Spacing (GHz).

W: take values S (short-haul), L (long-haul).

y: take values 1 (NRZ 2.5G), 2 (indicating NRZ 10G).

t: take only D value is defined (link does not contain optical amplifier)

z: take values 2 (ITU-T G.652 fibre), 3 (ITU-T G.653 fibre), 5 (indicating ITU-T G.655 fibre).

v: take values S (Short wavelength), C (Conventional), L (Long wavelength).

An Optional F can be added indicating a FEC Encoding.

These get mapped into the 64 bit OIC field 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|B|  p  |S|   c   |   W   |   y   |   t   |   z   |  v  |   s   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            reserved                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where (values between parenthesis refer to ITU defined values as reported above):

B: = 1 bidirectional, 0 otherwise

p (prefix): = 0 reserved, = 1 (D)

S: = 0 (N), = 1 (W)

c: Channel Spacing, 4 bits mapped according to same definition in [RFC6205] (note that DWDM spacing apply here)

W: = 0 reserved, = 2 (S), = 3 (L)

y: = 0 reserved, = 1 (1), = 2 (2)

t: = 0 reserved, = 4 (D)

z: = 0 reserved, = 2 (2), = 3 (3), = 5 (5) v: = 0 reserved, = 1 (S), = 2 (C), = 3 (L)

s (suffix): = 0 reserved, = 1 Fec Encoding

Values not mentioned here are not allowed in this application code, the last 32 bits are reserved and shall be set to zero.

5.2.3. ITU-G.698.2 Application Code Mapping

Recommendation ITU-G.698.2 defines the Application Codes: DScW-ytz(v) and B-DScW-ytz(v).

B: means Bidirectional.

D: means a DWDM application.

S: take values N (narrow spectral excursion), W (wide spectral excursion).

c: Channel Spacing (GHz).

W: take values C (link is dispersion compensated), U (link is dispersion uncompensated).

y: take values 1 (NRZ 2.5G), 2 (indicating NRZ 10G).

t: take value A (link may contains optical amplifier)

z: take values 2 (ITU-T G.652 fibre), 3 (ITU-T G.653 fibre), 5 (indicating ITU-T G.655 fibre).

v: take values S (Short wavelength), C (Conventional), L (Long wavelength).

An Optional F can be added indicating a FEC Encoding.

These get mapped into the 64 bit OIC field 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|B|  p  |S|   c   |   W   |   y   |   t   |   z   |  v  |   s   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           reserved                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where (values between parenthesis refer to ITU defined values as reported above):

B: = 1 bidirectional, 0 otherwise

p (prefix): = 0 reserved, = 1 (D)

S: = 0 (N), = 1 (W)

c: Channel Spacing, 4 bits mapped according to same definition in [RFC6205] (note that DWDM spacing apply here)

W: = 0 reserved, = 10 (C), = 11 (U)

y: = 0 reserved, = 1 (1), = 2 (2)

t: = 0 reserved, = 1 (A)

z: = 0 reserved, = 2 (2), = 3 (3), = 5 (5)

v: = 0 reserved, = 1 (S), = 2 (C), = 3 (L)

s (suffix): = 0 reserved, = 1 Fec Encoding

Values not mentioned here are not allowed in this application code, the last 32 bits are reserved and shall be set to zero.

5.2.4. ITU-G.959.1 Application Code Mapping

Recommendation ITU-G.959.1 defines the Application Codes: PnWx-ytz and BnWx-ytz. Where:

P,B: when present indicate Plural or Bidirectional

n: maximum number of channels supported by the application code (i.e. an integer number)

W: take values I (intra-office), S (short-haul), L (long-haul), V (very long-haul), U (ultra long-haul).

x: maximum number of spans allowed within the application code (i.e. an integer number) y: take values 1 (NRZ 2.5G), 2 (NRZ 10G), 9 (NRZ 25G), 3 (NRZ 40G), 7 (RZ 40G).

t: take values A (power levels suitable for a booster amplifier in the originating ONE and power levels suitable for a pre-amplifier in the terminating ONE), B (booster amplifier only), C (pre-amplifier only), D (no amplifiers).

z: take values 1 (1310 nm sources on ITU-T G.652 fibre), 2 (1550 nm sources on ITU-T G.652 fibre), 3 (1550 nm sources on ITU-T G.653 fibre), 5 (1550 nm sources on ITU-T G.655 fibre).

The following list of suffixes can be added to these application codes:

F: FEC encoding.

D: Adaptive dispersion compensation.

E: receiver capable of dispersion compensation.

r: reduced target distance.

a: power levels appropriate to APD receivers.

b: power levels appropriate to PIN receivers.

These values are encoded 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| p |  P  |        n          |   W   |     x     |   reserved  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   y   |   t   |   z   |   suffix  |          reserved         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where (values between parenthesis refer to ITU defined values as reported above):

p (prefix) = 0 otherwise, = 1 Bidirectional (B)

P (optional): = 0 not present, = 2 (P).

n: maximum number of channels (10 bits, up to 1024 channels)

W: = 0 reserved, = 1 (I), = 2 (S), = 3 (L), = 4 (V), = 5 (U)

x: = number of spans (6 bits, up to 64 spans)

y: = 0 reserved, = 1 (1), = 2 (2), = 3 (3), = 7 (7), = 9 (9)

t: = 0 reserved, = 1 (A), = 2 (B), = 3 (C), = 4 (D)

z: = 0 reserved, = 1 (1), = 2 (2), = 3 (3), = 5 (5)

suffix is an 6 bit, bit map:

```
 0 1 2 3 4 5
+-+-+-+-+-+-+
|F|D|E|r|a|b|
+-+-+-+-+-+-+
```

where a 1 in the appropriate slot indicates that the corresponding suffix has been added.

5.2.5. ITU-G.695 Application Code Mapping

Recommendation [ITU-G.695] defines the Application Codes: CnWx-ytz and B-CnWx-ytz and S-CnWx-ytz.

Where the optional prefixed are:

B: Bidirectional

S: a system using a black link approach

And the rest of the application code is defined as:

C: CWDM (Coarse WDM) application

n: maximum number of channels supported by the application code (i.e. an integer number)

W: take values S (short-haul), L (long-haul).

x: maximum number of spans allowed

y: take values 0 (NRZ 1.25G), 1 (NRZ 2.5G), 2 (NRZ 10G).

t: take values D (link does not contain any optical amplifier).

z: take values 1 (1310 nm region for ITU-T G.652 fibre), 2 (ITU-T G.652 fibre), 3 (ITU-T G.653 fibre), 5 (ITU-T G.655 fibre).

The following list of suffixes can be added to these application codes:

F: FEC encoding.

Since the application codes are very similar to the one from the G.959 section most of the fields are reused. The 64 bit OIC field is encoded 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| p |  C  |       n          |   W   |     x     |   reserved  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   y   |   t   |   z   |  suffix |          reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where (values between parenthesis refer to ITU defined values as reported above):

p: = 0 no prefix, 1 = B bidirectional, = 2 S black link

C: = 0 reserved, = 3 (C).

n: maximum number of channels (10 bits, up to 1024 channels)

W: = 0 reserved, = 1 reserved, = 2 (S), = 3 (L), > 3 reserved

x: = number of spans (6 bits, up to 64 spans)

y: = 0 (0), = 1 (1), =2 (2), > 2 reserved

t: = 4 (D), all other values are reserved

z: = 0 reserved, = 1 (1), = 2 (2), = 3 (3)

suffix is an 6 bit, bit map:

```
  0 1 2 3 4 5
 +-+-+-+-+-+-+
 |F|0|0|0|0|0|
 +-+-+-+-+-+-+
```

where a 1 in the appropriate slot indicates that the corresponding suffix has been added.

5.3. Input Client Signal List Sub-Sub-TLV

This sub-sub-TLV contains a list of acceptable input client signal types.

Type := Input Client Signal List

Value := A list of GPIDs

The acceptable client signal list sub-TLV is a list of Generalized Protocol Identifiers (GPIDs). GPIDs are assigned by IANA and many are defined in [RFC3471] and [RFC4328].

```
      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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |       Number of GPIDs         |          GPID #1              |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     :                               |                               :
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |            GPID #N            |                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where the number of GPIDs is an integer greater than or equal to one.

5.4. Processing Capability List Sub-Sub-TLV

This sub-sub-TLV contains a list of resource processing capabilities.

Type := Processing Capabilities List

Value := A list of Processing Capabilities Fields

The processing capability list sub-sub-TLV is a list of capabilities that can be achieved through the referred resources::

1. Regeneration capability

2. Fault and performance monitoring

3. Vendor Specific capability

Note that the code points for Fault and performance monitoring and vendor specific capability are subject to further study.

5.4.1. Processing Capabilities Field

The processing capability field is then given by:

```
      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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |          Processing Cap ID    |          Length               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |   Possible additional capability parameters depending upon    |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     :   the processing ID                                           :
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

When the processing Cap ID is "regeneration capability", the following additional capability parameters are provided in the sub-TLV:

```
      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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |  T  | C |                 Reserved                            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where T bit indicates the type of regenerator:

T=0: Reserved

T=1: 1R Regenerator

T=2: 2R Regenerator

T=3: 3R Regenerator

Where C bit indicates the capability of regenerator:

C=0: Reserved

C=1: Fixed Regeneration Point

C=2: Selective Regeneration Point

Note that when the capability of regenerator is indicated to be Selective Regeneration Pools, regeneration pool properties such as input and output restrictions and availability need to be specified. This encoding is to be determined in the later revision.

6. Security Considerations

This document defines protocol-independent encodings for WSON information and does not introduce any security issues.

However, other documents that make use of these encodings within protocol extensions need to consider the issues and risks associated with, inspection, interception, modification, or spoofing of any of this information. It is expected that any such documents will describe the necessary security measures to provide adequate protection.

7. IANA Considerations

This document provides general protocol independent information encodings. There is no IANA allocation request for the TLVs defined in this document. IANA allocation requests will be addressed in protocol specific documents based on the encodings defined here.

8. Acknowledgments

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APPENDIX A: Encoding Examples

A.1. Wavelength Converter Accessibility Sub-TLV

Example:

Figure 1 shows a wavelength converter pool architecture know as "shared per fiber". In this case the input and output pool matrices are simply:

```
              +-----+       +-----+
              | 1 1 |       | 1 0 |
          WI =|     |,  WE =|     |
              | 1 1 |       | 0 1 |
              +-----+       +-----+
```

```
                    +-----------+                      +------+
                    |           |--------------------->|      |
                    |           |--------------------->|  C   |
              /|    |           |--------------------->|  o   |
             /D+--->|           |--------------------->|  m   |
            + e+--->|           |                      |  b   |=======>
   ========>| M|    |  Optical  |    +-----------+     |  i   | Port E1
   Port I1  + u+--->|   Switch  |    |  WC Pool  |     |  n   |
             \x+--->|           |    |  +-----+  |     |  e   |
              \|    |           +----+->|WC #1|--+---->|  r   |
                    |           |    |  +-----+  |     +------+
                    |           |    |           |     +------+
              /|    |           |    |  +-----+  |     |      |
             /D+--->|           +----+->|WC #2|--+---->|  C   |
            + e+--->|           |    |  +-----+  |     |  o   |
   ========>| M|    |           |    +-----------+     |  m   |=======>
   Port I2  + u+--->|           |                      |  b   | Port E2
             \x+--->|           |--------------------->|  i   |
              \|    |           |--------------------->|  n   |
                    |           |--------------------->|  e   |
                    |           |--------------------->|  r   |
                    +-----------+                      +------+
```

Figure 1 An optical switch featuring a shared per fiber wavelength converter pool architecture.

This wavelength converter pool can be encoded 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
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      | Connectivity=1|                    Reserved                   |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                 Note: I1,I2 can connect to either WC1 or WC2
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Action=0     |0|  Reserved   |            Length = 12        |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                     Link Local Identifier = #1                |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                     Link Local Identifier = #2                |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Action=0     |1|  Reserved   |            Length = 8         |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                           RB ID = #1                          |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                           RB ID = #2                          |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Note: WC1 can only connect to E1
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Action=0     |1|  Reserved   |            Length = 8         |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                     Link Local Identifier = #1                |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Action=0     |0|  Reserved   |            Length = 8         |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                            RB ID = #1                         |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Note: WC2 can only connect to E2
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Action=0     |1|  Reserved   |            Length = 8         |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                     Link Local Identifier = #2                |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Action=0     |0|              |            Length = 8        |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                            RB ID = #2                         |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

A.2. Wavelength Conversion Range Sub-TLV

Example:

This example, based on figure 1, shows how to represent the wavelength conversion range of wavelength converters. Suppose the wavelength range of input and output of WC1 and WC2 are {L1, L2, L3, L4}:

```
    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
                              Note: WC Set
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Action=0     |1| Reserved    |     Length = 8                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           WC ID = #1          |       WC ID = #2              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                              Note: wavelength input range
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | 2   | Num Wavelengths = 4     |          Length = 8           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Grid |  C.S. |     Reserved    |  n for lowest frequency = 1   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                              Note: wavelength output range
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | 2   | Num Wavelengths = 4     |          Length = 8           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |Grid |  C.S. |     Reserved    |  n for lowest frequency = 1   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

A.3. An OEO Switch with DWDM Optics

Figure 2 shows an electronic switch fabric surrounded by DWDM optics. In this example the electronic fabric can handle either G.709 or SDH signals only (2.5 or 10 Gbps). To describe this node, the following information is needed:

<Node_Info> ::= <Node_ID>[Other GMPLS sub-TLVs][<ConnectivityMatrix>...] [<ResourcePool>][<RBPoolState>]

In this case there is complete port to port connectivity so the <ConnectivityMatrix> is not required. In addition since there are sufficient ports to handle all wavelength signals the <RBPoolState> element is not needed.

Hence the attention will be focused on the <ResourcePool> sub-TLV:

<ResourcePool> ::= <ResourceBlockInfo>[<ResourceBlockAccessibility>...][<ResourceWaveConstraints>...]

```
              /|    +-----------+    +-------------+   +------+
             /D+--->|           +--->|Tunable Laser|-->|      |
            + e+--->|           |    +-------------+   |  C   |
   ========>| M|    |           |        ...        |  o   |=======>
   Port I1  + u+--->|           |    +-------------+   |  m   | Port E1
             \x+--->|           |--->|Tunable Laser|-->|  b   |
              \|    |  Electric |    +-------------+   +------+
                    |   Switch  |
              /|    |           |    +-------------+   +------+
             /D+--->|           +--->|Tunable Laser|-->|      |
            + e+--->|           |    +-------------+   |  C   |
   ========>| M|    |           |        ...        |  o   |=======>
   Port I2  + u+--->|           |    +-------------+   |  m   | Port E2
             \x+--->|           +--->|Tunable Laser|-->|  b   |
              \|    |           |    +-------------+   +------+
                    |           |
              /|    |           |    +-------------+   +------+
             /D+--->|           |--->|Tunable Laser|-->|      |
            + e+--->|           |    +-------------+   |  C   |
   ========>| M|    |           |        ...        |  o   |=======>
   Port I3  + u+--->|           |    +-------------+   |  m   | Port E3
             \x+--->|           |--->|Tunable Laser|-->|  b   |
              \|    +-----------+    +-------------+   +------+
```

Figure 2 An optical switch built around an electronic switching fabric.

The resource block information will tell us about the processing constraints of the receivers, transmitters and the electronic switch. The resource availability information, although very simple, tells us that all signals must traverse the electronic fabric (fixed connectivity). The resource wavelength constraints are not needed since there are no special wavelength constraints for the resources that would not appear as port/wavelength constraints.

<ResourceBlockInfo>:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     RB Set Field                              |
:  (only one resource block in this example with shared         |
|                     input/output case)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|1|1|                   Reserved                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       Optical Interface Class List(s) Sub-Sub-TLV             |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Input Client Signal Type Sub-TLV                 |
:              (GPIDs for SDH and G.709)                        :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Input Bit Rate Range List  Sub-Sub-TLV              |
:                       (2.5Gbps, 10Gbps)                       :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Processing Capabilities List Sub-Sub-TLV              |
:                    Fixed (non optional) 3R regeneration       :
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Since there is fixed connectivity to resource blocks (the electronic switch) the <ResourceBlockAccessibility> is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Connectivity=0|Reserved       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Input Link Set Field A #1                  |
:                    (All input links connect to resource)      :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          RB Set Field A #1                    |
:              (trivial set only one resource block)            :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Output Link Set Field B #1                     |
:                    (All output links connect to resource)     :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

9. References

9.1. Normative References

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