Internet Engineering Task Force (IETF)
Request for Comments: 7581
Category: Standards Track
ISSN: 2070-1721

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June 2015

Routing and Wavelength Assignment Information Encoding for Wavelength Switched Optical Networks

Abstract

A Wavelength Switched Optical Network (WSON) requires certain key information fields be made available to facilitate path computation and the establishment of Label Switched Paths (LSPs). The information model described in "Routing and Wavelength Assignment Information Model for Wavelength Switched Optical Networks" (RFC 7446) 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 specific to WSONs.

This document provides efficient, protocol-agnostic encodings for the WSON-specific information fields. 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).

Status of This Memo

This is an Internet Standards Track document.

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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, [RFC7446] 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 PCE. Note that since these encodings are efficient, they can provide more accurate analysis of the control-plane communications/processing load for WSONs looking to utilize a GMPLS control plane.

In parallel to this document, [RFC7579] provides efficient encodings of information needed by the routing and label assignment process that are potentially applicable to a wider range of technologies.

1.1. Terminology

Refer to [RFC6163] for definitions of the following:

- Coarse Wavelength Division Multiplexing (CWDM)
- Dense Wavelength Division Multiplexing (DWDM)
- Routing and Wavelength Assignment (RWA)
- Wavelength Division Multiplexing (WDM)

Refer to Section 5 of [RFC7446] for definitions of the following:

- resource
- resource block
- resource pool

The Optical Interface (OI) Code Point is a unique number that identifies all information related to optical characteristics of a physical interface.

1.2. 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].

2. Resources, Resource Blocks, and the Resource Pool

This section provides encodings for the information fields defined in [RFC7446] that have applicability to WSON. The encodings are designed to be suitable for use in the GMPLS routing protocols OSPF [RFC4203] and IS-IS [RFC5307] and in the PCE Communication Protocol (PCEP) [RFC5440]. Note that the information distributed in [RFC4203] and [RFC5307] is arranged via the nesting of sub-TLVs within TLVs; this document defines elements to be used within such constructs. Specific constructs of sub-TLVs and the nesting of sub-TLVs of the information fields defined by this document will be defined in the respective protocol enhancement documents.

This document defines the following information fields pertaining to resources within an optical node:

- Resource Accessibility <ResourceAccessibility>
- Resource Wavelength Constraints <ResourceWaveConstraints>
- Resource Block Pool State <RBPoolState>
- Resource Block Shared Access Wavelength Availability <RBSharedAccessWaveAvailability>
- Resource Block Information <ResourceBlockInfo>

Each of these information fields works with one or more sets of resources rather than just a single resource block. This motivates the field definition in Section 2.1.

2.1. Resource Block Set Field

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

The information carried in an RB Set Field is defined 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    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 identifiers. 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 multicast) connectivity, and set to 1 to denote potential (switched) connectivity. Used in Resource Accessibility field. 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. The scope of the RB identifier is local to the node on which it is applied.

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

3. Resource Accessibility/Availability

This section defines the information fields for dealing with accessibility and availability of resource blocks within a pool of resources. These include the <ResourceAccessibility>, <ResourceWaveConstraints>, <RBPoolState>, and <RBSharedAccessWaveAvailability> fields.

3.1. Resource Accessibility Field

This information field 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 the ability of sets of resources to reach a particular output port. This is the <PoolInputMatrix> and <PoolOutputMatrix> of [RFC7446].

The Resource Accessibility field is defined 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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |Reserved(8bits)|C|           Reserved (23 bits)                |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                    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:

C (Connectivity bit): 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)

For the Input and Output Link Set Fields, the Link Set Field encoding defined in [RFC7579] 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 field.

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

3.2. Resource Wavelength Constraints Field

Resources, such as wavelength converters, etc., may have 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 Constraints fields 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 Constraints                   |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Output Wavelength Constraints                  |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

I (Input):

1 - indicates the presence of the Input Wavelength Constraints field

0 - indicates otherwise.

O (Output):

1 - indicates the presence of the Output Wavelength Constraints field

0 - indicates otherwise.

B (Both):

1 - indicates that a single Wavelength Constraints field represents both Input and Output Wavelength Constraints fields.

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

RB Set Field:

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

Input Wavelength Constraints:

Indicates the wavelength input restrictions of the RBs in the corresponding RB set. This field is encoded via the Label Set Field of [RFC7579].

Output Wavelength Constraints:

Indicates the wavelength output restrictions of RBs in the corresponding RB set. This field is encoded via the Label Set Field of [RFC7579].

3.3. Resource Block Pool State Field

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 bitmap indicating whether a single resource is available or in use. The bitmap 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 bitmap. Action = 0 covers the case where there are multiple elements for each resource block. Action = 1 covers the case where each resource block only contains a single element.

In both cases, the elements of the RB Set Field are in a one-to-one correspondence with the values in the 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      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

RB#i State (16 bits, unsigned integer): Indicates the number of resources available in Resource Block #i.

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 Bitmap: Variable length but must be a multiple of 4 bytes.

Each bit indicates the usage status of one RB with 0 indicating the RB is available and 1 indicating the RB is in use. The sequence of the bitmap is ordered according to the RB Set Field with this element.

Padding bits: Variable length

3.4. Resource Block Shared Access Wavelength Availability Field

Resource 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|O|B|                        Reserved                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      RB Set Field                             |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Input Available Wavelength Set Field                |
:                          (Optional)                           :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Output Available Wavelength Set Field              |
:                          (Optional)                           :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

I (Input):

1 - indicates the presence of the Input Available Wavelength Set Field.

0 - indicates the absence of the Input Available Wavelength Set Field.

O (Output):

1 - indicates the presence of the Output Available Wavelength Set Field.

0 - indicates the absence of the Output Available Wavelength Set Field.

B (Both):

1 - indicates that a single Available Wavelength Set Field represents both Input and Output Available Wavelength Set Fields.

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

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 [RFC7579].

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 [RFC7579].

4. Resource Block Information Field

As defined in [RFC7446], the Resource Block Information <ResourceBlockInfo> field is used to represent resource signal constraints and processing capabilities of a node.

The fundamental properties of a resource block are:

- o Optical Interface Class List(s)
- o Acceptable Client Signal (shared input, modulation, Forward Error Correction (FEC), bit rate, and Generalized Protocol Identifier (G-PID))
- o Input Bit Rate
- o Processing Capabilities (number of resources in a block, regeneration, performance monitoring, vendor specific)

<ResourceBlockInfo> fields are used to convey relatively static information about individual resource blocks, including the resource block properties and the number of resources in a block.

When more than one <ResourceBlockInfo> field is used, there are no ordering requirements amongst these fields. The length of the <ResourceBlockInfo> field is determined from the length of the object that includes it.

The <ResourceBlockInfo> field 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|O|B|                        Reserved                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Optional Subfield 1                    |
:                              ...                              :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                               :                               :
:                               :                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Optional Subfield N                    |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The RB Set Field is described in Section 2.1.

The shared input or output indication is indicated by the first bit (I), the second bit (O), and the third bit (B).

I (Input):

1 - indicates if the resource blocks identified in the RB Set Field utilized a shared fiber for input access.

0 - indicates otherwise.

O (Output):

1 - indicates if the resource blocks identified in the RB Set Field utilized a shared fiber for output access.

0 - indicates otherwise.

B (Both):

1 - indicates if the resource blocks identified in the RB Set Field utilized a shared fiber for both input and output access.

0 - indicates otherwise.

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

Zero or more Optional Subfields MAY be present. Optional Subfields have 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Value...                           |
.                                                               .
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Length field defines the length of the value portion in bytes (thus, a subfield with no value portion would have a length of zero). The subfield is padded to 4-byte alignment; padding is not included in the Length field (so a 3-byte value would have a length of three, but the total size of the subfield would be 8 bytes). Unrecognized types are not processed. If multiple subfields of the same type are present, only the first of the type SHOULD be processed.

The following sub-TLV types are defined:

Value	Length	Sub-TLV Type
1	variable	Optical Interface Class List
2	variable	Acceptable Client Signal List
3	variable	Input Bit Rate List
4	variable	Processing Capability List

See the IANA Considerations section for allocation of new types.

4.1. Optical Interface Class List Subfield

The Optical Interface Class List subfield 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Reserved                       |I|O|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Optical Interface Classes                  |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The following I and O combination are defined:

```
I   O
-----
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 the input/output flags.

The Optical Interface Classes format is defined 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|     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 semantics of the Optical Interface Class in the following way:

S (Standard bit):

S=0: identifies non-ITU code points

S=1: identifies ITU application codes

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

0: reserved

Future work may add support for vendor-specific application codes once the ITU-T has completed its work in that area.

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

0: reserved

1: [G.698.1] application code

2: [G.698.2] application code

3: [G.959.1] application code

4: [G.695] application code

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

4.1.1. ITU-T G.698.1 Application Code Mapping

[G.698.1] defines the following application codes: DScW-ytz(v) and B-DScW-ytz(v). Where:

B: means Bidirectional

D: means a DWDM application

S: takes values N (narrow spectral excursion) or W (wide spectral excursion)

c: Channel Spacing (GHz)

W: takes values S (short-haul) or L (long-haul)

y: takes values 1 (NRZ 2.5G) or 2 (NRZ 10G)

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

z: takes values 2 ([G.652] fibre), 3 ([G.653] fibre), or 5 ([G.655] fibre)

v: takes values S (Short wavelength), C (Conventional), or L (Long wavelength)

The F flag indicates the presence or absence of an optional FEC encoding suffix.

These get mapped into the 64-bit Optical Interface Class 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|  D  |S|   c   |   W   |   y   |   t   |   z   |  v  |   F   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            reserved                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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

B: 1 bidirectional, 0 otherwise

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

S: 0 (N), 1 (W)

c: Channel Spacing, 4 bits mapped according to the same definition as in the third figure in Section 3.2 of [RFC6205] (note that DWDM spacing applies 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)

F (suffix): 0 No FEC encoding suffix present, 1 FEC encoding suffix present

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

4.1.2. ITU-T G.698.2 Application Code Mapping

[G.698.2] defines the following application codes: DScW-ytz(v) and B-DScW-ytz(v). Where:

B: means Bidirectional

D: means a DWDM application

S: takes values N (narrow spectral excursion) or W (wide spectral excursion)

c: Channel Spacing (GHz)

W: takes values C (link is dispersion compensated) or U (link is dispersion uncompensated)

y: takes values 1 (NRZ 2.5G) or 2 (NRZ 10G)

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

z: takes values 2 ([G.652] fibre), 3 ([G.653] fibre), or 5 ([G.655] fibre)

v: takes values S (Short wavelength), C (Conventional), or L (Long wavelength)

An optional F can be added to indicate a FEC encoding.

These get mapped into the 64-bit Optical Interface Class 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|  D  |S|   c   |   W   |   y   |   t   |   z   |  v  |   F   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           reserved                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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

B: 1 bidirectional, 0 otherwise

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

S: 0 (N), 1 (W)

c: Channel Spacing, 4 bits mapped according to the same definition as in the third figure in Section 3.2 of [RFC6205] (note that DWDM spacing applies 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)

F (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.

4.1.3. ITU-T G.959.1 Application Code Mapping

[G.959.1] defines the following 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: takes values I (intra-office), S (short-haul), L (long-haul), V (very long-haul), or U (ultra long-haul)

x: maximum number of spans allowed within the application code (i.e., an integer number)

y: takes values 1 (NRZ 2.5G), 2 (NRZ 10G), 9 (NRZ 25G), 3 (NRZ 40G), or 7 (RZ 40G)

t: takes 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), or D (no amplifiers)

z: takes values 1 (1310 nm sources on [G.652] fibre), 2 (1550 nm sources on [G.652] fibre), 3 (1550 nm sources on [G.653] fibre), or 5 (1550 nm sources on [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 parentheses 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 1023 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: a 6-bit bitmap, where a "1" in the appropriate slot indicates that the corresponding suffix has been added.

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

4.1.4. ITU-T G.695 Application Code Mapping

[G.695] defines the following application codes: CnWx-ytz, B-CnWx-ytz, and S-CnWx-ytz.

Where the optional prefixes 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: takes values S (short-haul) or L (long-haul)

x: maximum number of spans allowed

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

t: takes value D (link does not contain any optical amplifier).

z: takes values 1 (1310 nm region for [G.652] fibre), 2 (ITU-T [G.652] fibre), 3 ([G.653] fibre), or 5 ([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 ones from the [G.959.1] section, most of the fields are reused. The 64-bit Optical Interface Class 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 parentheses 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 1023 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: a 6-bit bitmap, where a "1" in the appropriate slot indicates that the corresponding suffix has been added.

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

4.2. Acceptable Client Signal List Subfield

This subfield contains a list of acceptable input client signal types.

The acceptable client signal list is a list of Generalized Protocol Identifiers (G-PIDs).

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Reserved           |       Number of G-PIDs        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            G-PID #1           |          G-PID #2             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                               |                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            G-PID #N           |                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Number of G-PIDs: an integer greater than or equal to one.

G-PIDs: assigned by IANA. Many are defined in [RFC3471] and [RFC4328].

4.3. Input Bit Rate List Subfield

This subfield contains a list of bit rates of each input client signal type specified in the Input Client Signal List.

The number of Input Bit Rates MUST match the number of G-PIDs.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Input Bit Rate of G-PID #1                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Input Bit Rate of G-PID #N                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Input Bit Rates are in IEEE 754 floating point format [IEEE].

4.4. Processing Capability List Subfield

The Processing Capability List subfield 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

Fault and performance monitoring and vendor-specific capability have no additional capability parameters.

The Processing Capability List subfield is defined as:

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

The Processing Cap ID field defines the following processing capabilities:

0: Reserved

1: Regeneration capability

2: Fault and performance monitoring

3: Vendor-specific capability

When the Processing Cap ID is "Regeneration capability", the following additional capability parameters are provided in the following 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  T  | C |                 Reserved                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Where the T bit indicates the type of regenerator:

T=0: Reserved

T=1: 1R Regenerator

T=2: 2R Regenerator

T=3: 3R Regenerator

And where the C bit indicates the capability of the regenerator:

C=0: Reserved

C=1: Fixed Regeneration Point

C=2: Selective Regeneration Pools

Note that when the capability of the regenerator is indicated to be "Selective Regeneration Pools", regeneration pool properties such as input and output restrictions and availability need to be specified. These properties will be encoded in the field providing additional capability parameters, starting with the bits marked Reserved in the figure immediately above. An additional specification describing the encoding of these parameters is required before the value C=2 can be used.

5. 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. A general discussion on security in GMPLS networks can be found in [RFC5920].

6. IANA Considerations

This document introduces a new top-level registry for GMPLS routing parameters for WSON encoding. This new IANA registry has been created to make the assignment of a new type and new values for the new "GMPLS Routing Parameters for WSON" registry. Note that this registry is only used in routing, not in signaling.

6.1. Types for Subfields of WSON Resource Block Information

Under the new "GMPLS Routing Parameters for WSON" registry, a new IANA subregistry has been created for nested subfields of the Resource Block Information field to create a new section named "Types for Subfields of WSON Resource Block Information Registry". This registry will be maintained via Standards Action as defined by [RFC5226].

The initial values in the registry are as follows:

Value	Length	Description	Reference
0		Reserved	
1	variable	Optical Interface Class List	[RFC7581]
2	variable	Acceptable Client Signal List	[RFC7581]
3	variable	Input Bit Rate List	[RFC7581]
4	variable	Processing Capability List	[RFC7581]
5-65535		Unassigned	

7. References

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Appendix A. Encoding Examples

A.1. Wavelength Converter Accessibility Field

Figure 1 shows a wavelength converter pool architecture known 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 O1
   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 O2
             \x+--->|           |--------------------->|  i   |
              \|    |           |--------------------->|  n   |
                    |           |--------------------->|  e   |
                    |           |--------------------->|  r   |
                    +-----------+                      +------+
```

Figure 1: An Optical Switch Featuring a Shared Per-Fiber Wavelength Converter Pool Architecture

The wavelength converters are resource blocks and the wavelength converter pool is a resource block pool. This 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Reserved |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 O1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  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 O2
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Action=0     |1|  Reserved   |            Length = 8         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Link Local Identifier = #2                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Action=0     |0|              |            Length = 8        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            RB ID = #2                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

A.2. Wavelength Conversion Range Field

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 Synchronous Digital Hierarchy (SDH) signals only (2.5 or 10 Gbps). To describe this node, the following information in Reduced Backus-Naur Form (RBNF) form [RFC5511] is needed:

```
<Node_Info> ::= <Node_ID>

                [Other GMPLS info-elements]

                [<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> field:

```
<ResourcePool> ::= <ResourceBlockInfo>

                   [<RBAccessibility>...]

                   [<ResourceWaveConstraints>...]
```

```
              /|    +-----------+    +-------------+   +------+
             /D+--->|           +--->|Tunable Laser|-->|      |
            + e+--->|           |    +-------------+   |  C   |
   ========>| M|    |           |        ...           |  o   |=======>
   Port I1  + u+--->|           |    +-------------+   |  m   | Port O1
             \x+--->|           |--->|Tunable Laser|-->|  b   |
              \|    |  Electric |    +-------------+   +------+
                    |   Switch  |
              /|    |           |    +-------------+   +------+
             /D+--->|           +--->|Tunable Laser|-->|      |
            + e+--->|           |    +-------------+   |  C   |
   ========>| M|    |           |        ...           |  o   |=======>
   Port I2  + u+--->|           |    +-------------+   |  m   | Port O2
             \x+--->|           +--->|Tunable Laser|-->|  b   |
              \|    |           |    +-------------+   +------+
                    |           |
              /|    |           |    +-------------+   +------+
             /D+--->|           |--->|Tunable Laser|-->|      |
            + e+--->|           |    +-------------+   |  C   |
   ========>| M|    |           |        ...           |  o   |=======>
   Port I3  + u+--->|           |    +-------------+   |  m   | Port O3
             \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.

The <ResourceBlockInfo> 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      RB Set Field                             |
:  (only one resource block in this example with shared         |
|                      input/output case)                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|1|1|0|                   Reserved                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Optical Interface Class List(s)              |
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Input Client Signal Type                  |
:                    (G-PIDs for SDH and G.709)                 :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Input Bit Rate Range List                 |
:                       (2.5 Gbps, 10 Gbps)                     :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Processing Capabilities List               |
:              Fixed (non optional) 3R regeneration             :
:                                                               :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Since there is fixed connectivity to resource blocks (the electronic switch), the <RBAccessibility> 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)    :
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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