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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, [RWA-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.

1.1. Terminology

Refer to [[RFC6163](#)] for CWDM, DWDM, RWA, WDM.

Refer to Section 5 of [[Gen-Encode](#)] for the terminology of Resources, Resources Blocks, and Resource Pool.

2. Resources, Resource Blocks, and the Resource Pool

This section provides encodings for the information elements defined in [[RWA-Info](#)] 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 protocol (PCEP) [[RFC5440](#)]. Note that the information distributed in [[RFC4203](#)] and [[RFC5307](#)] is arranged via the nesting of sub-TLVs within TLVs and this document defines elements to be used within such constructs. Specific constructs of sub-TLVs and the nesting of sub-TLVs of the information element defined by this document will be defined in the respective protocol enhancement documents.

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

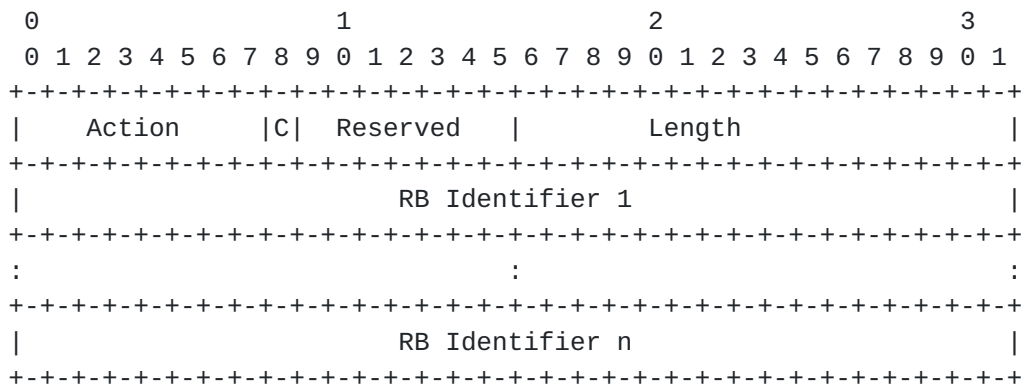
- . Resource Accessibility <ResourceAccessibility>
- . Resource Wavelength Constraints <ResourceWaveConstraints>
- . Resource Block Pool State <RBPoolState>
- . Resource Block Shared Access Wavelength Availability
 <RBSharedAccessWaveAvailability>
- . Resource Block Information <ResourceBlockInfo>

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

2.1. 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:



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 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.

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.

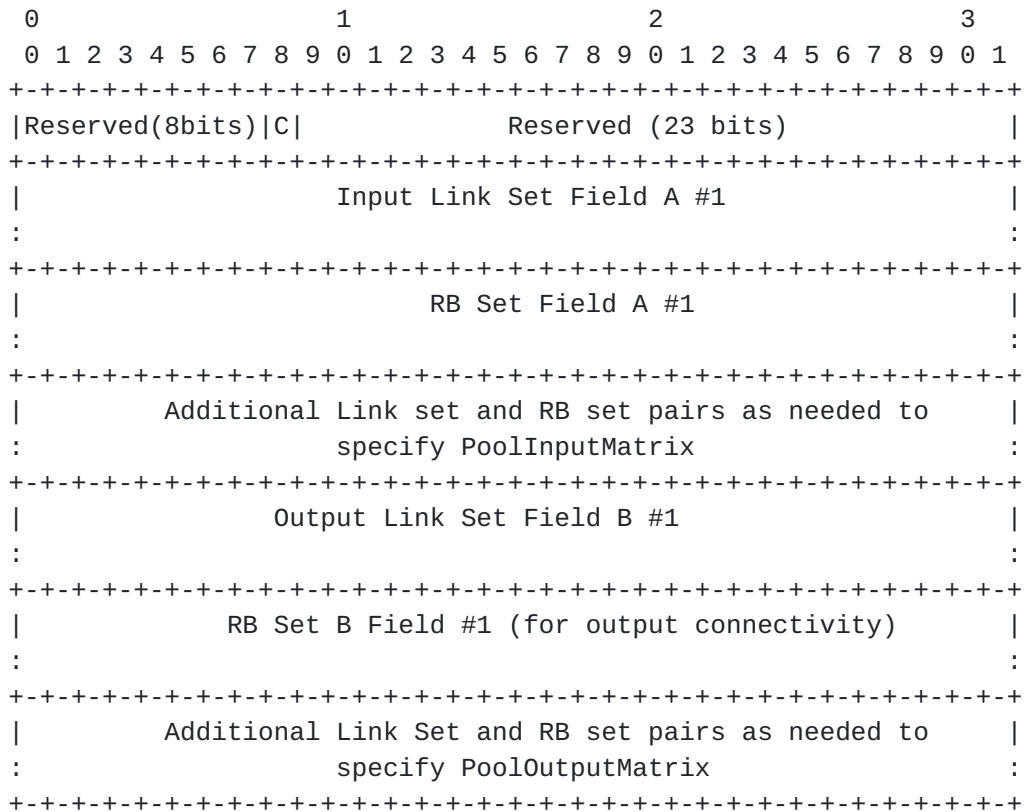
3. Resource Accessibility/Availability

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

3.1. Resource Accessibility Field

This information element 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 sets of resources to reach a particular output port. This is the PoolInputMatrix and PoolOutputMatrix of [[RWA-Info](#)].

The Resource Accessibility is defined by:



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)

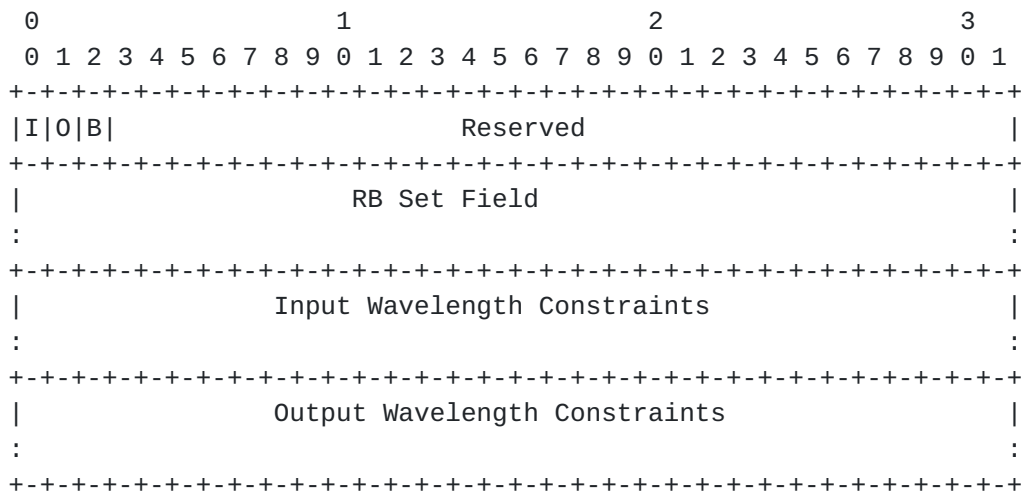
The For the Input and Output Link Set Fields, the Link Set Field encoding defined in [[Gen-Encode](#)] is to be used. A Label Set Field MUST carry a label as defined in [[RFC6205](#)].

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 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 fields as defined below:



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

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

B = 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 $(1, 0, 0)$, $(0, 1, 0)$, $(1, 1, 0)$, $(0, 0, 1)$.

RB Set Field:

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

Input Wavelength Constraints Field:

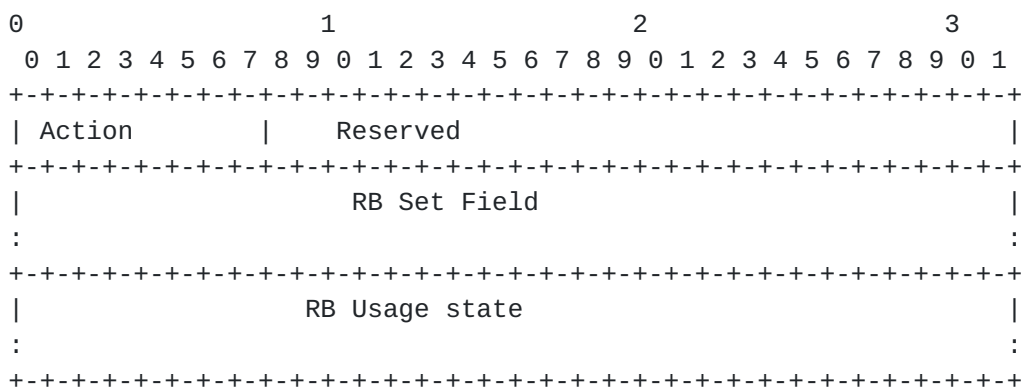
Indicates the wavelength input restrictions of the RBs in the corresponding RB set. This field is encoded via the Label Set field of [[Gen-Encode](#)].

Output Wavelength Constraints Field:

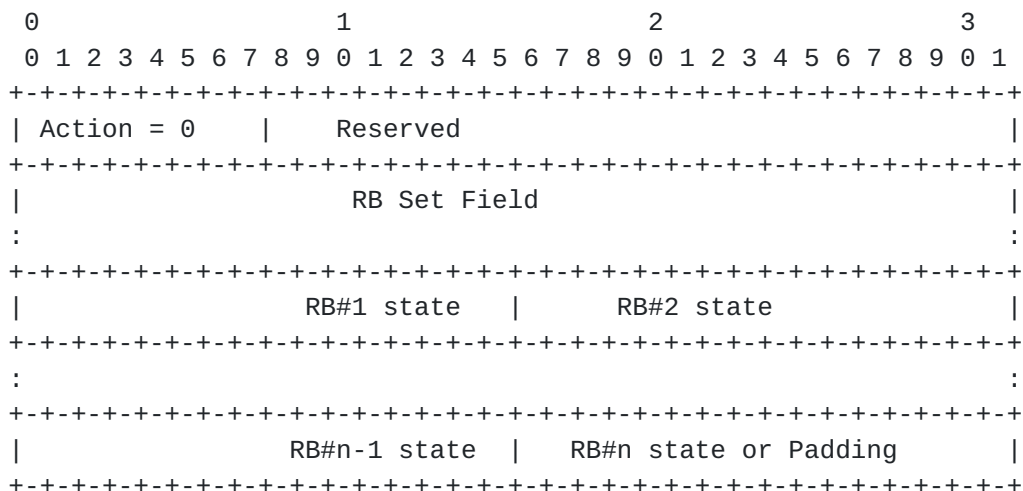
Indicates the wavelength output restrictions of RBs in the corresponding RB set. This field is encoded via the Label Set field of [[Gen-Encode](#)].

3.3. Resource Block Pool State (RBPoolState) 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 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).

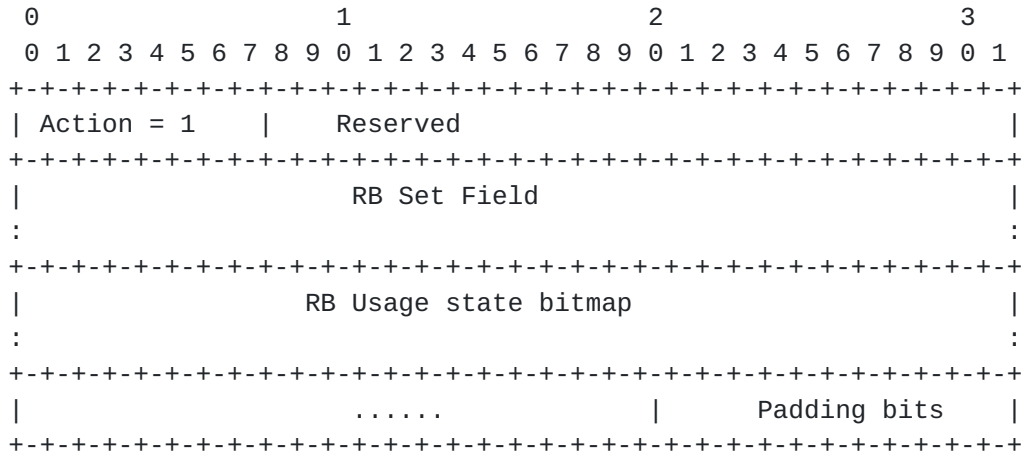


Where Action = 0 denotes a list of 16 bit integers and Action = 1 denotes a bit map. In both cases the elements of the RB Set field are in a one-to-one correspondence with the values in the usage RB usage state area.



RB#i State (16 bits, unsigned integer): indicates Resource Block #i is in use or available.

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.



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

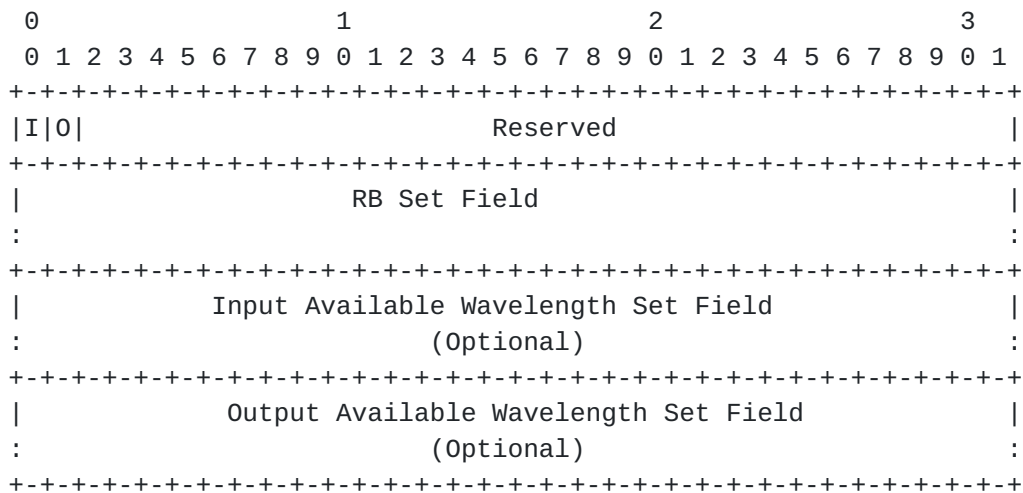
Each bit indicates the usage status of one RB with 0 indicating the RB is available and 1 indicating the RB is in used. The sequence of the bit map is ordered according to the RB Set field with this element.

Padding bits: Variable Length

3.4. Resource Block Shared Access Wavelength Availability

(RBSharedAccessWaveAvailability) Field

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.



I bit:

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

O 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](#)].

4. Resource Block Information (ResourceBlockInfo) Field

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

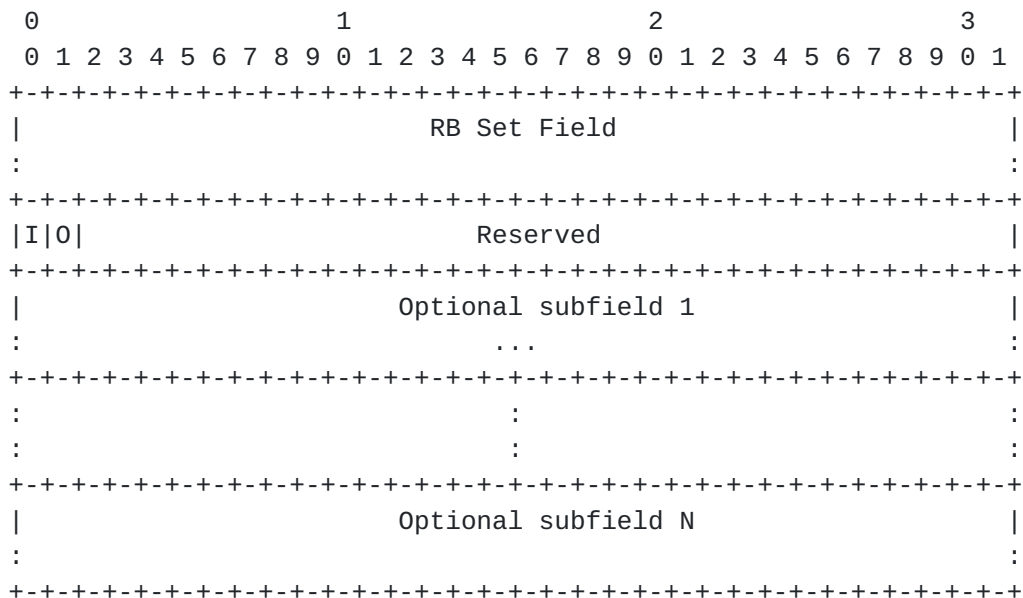
The fundamental properties of a resource block are:

- (a) Optical Interface Class List(s)
- (b) Acceptable Client Signal (shared input, modulation, FEC, bit rate, G-PID)
- (c) Input Bit Rate
- (d) 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.

This ResourceBlockInfo field has the following format:



4.1. Optical Interface Class List Subfield

The list of Optical Interface Class 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 E combination are defined:

```

I   0

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.

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 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] 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.

4.1.1. 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.

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 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.

4.1.2. 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	2	3	4	5	6	7	8	9
+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
	B			D			S			c			W			y			t			z			v			F											
+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
	reserved																																						
+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-

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

B: = 1 `bidirectional`, 0 otherwise

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

$$S: = 0 \quad (N), \quad = 1 \quad (W)$$

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)

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-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:

[illegible]

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.

4.1.4. 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:

[illegible]

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|
+-+--+--+--+

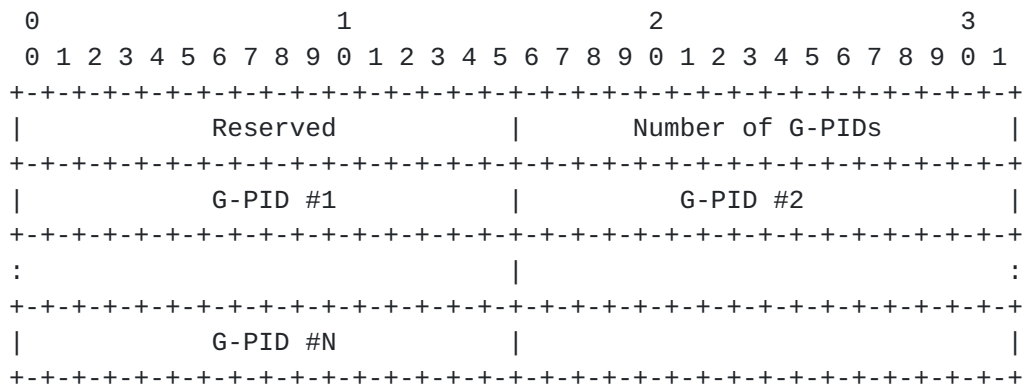
```

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

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).



Type (16 bits): identifies the Acceptable Client Signal List field.

Length (16 bits): The Length field defines the length of the value portion in octets.

The number of G-PIDs is an integer greater than or equal to one.

G-PIDs are assigned by IANA and many are defined in [[RFC3471](#)] and [[RFC4328](#)].

4.3. Input Bit Rate List Subfield

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

The number of Input Bit Rate MUST match the number of G-PID.

```

      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 floating point format [[IEEE](#)].

4.4. Processing Capability List Subfield

This subfield contains a list of resource processing capabilities.

The processing capability list field 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.

The processing capability list 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
+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
|           Reserved           |           Processing Cap ID           |
+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
| 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 following field:

[illegible]

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. The code point for this is subject to further study.

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

IANA allocation requests for protocol dependent encodings will be addressed in protocol specific documents based on the encodings defined here.

This document introduces a new registry for GMPLS routing parameters for WSON encoding. This new IANA registry will be created to make the assignment of a new type and new values for the new "GMPLS Routing Parameters for WSON."

6.1. Types for subfields of WSON Resource Block Information

Under this new GMPLS Routing Parameters for WSON, a new IANA registry will be created for nested subfields of the Resource Block Information field to create a new section named "Types for subfields of WSON Resource Block Information" and allocate new values as follows:

Value	Length	Sub-TLV Type	Reference
0		Reserved	
1	variable	Optical Interface Class List	[This.I-D]
2	variable	Acceptable Client	
		Signal List	[This.I-D]
3	variable	Input Bit Rate List	[This.I-D]
4	variable	Processing Capability List	[This.I-D]
5-65535		Unassigned	

Types are to be assigned via Standards Action as defined in [[RFC5226](#)].

7. Acknowledgments

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APPENDIX A: Encoding Examples

A.1. Wavelength Converter Accessibility Field

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:

$$\text{WI} = \begin{array}{c} +-----+ \\ | \ 1 \ 1 \ | \\ | \ 1 \ 1 \ | \\ +-----+ \end{array}, \quad \text{WE} = \begin{array}{c} +-----+ \\ | \ 1 \ 0 \ | \\ | \ 0 \ 1 \ | \\ +-----+ \end{array}$$

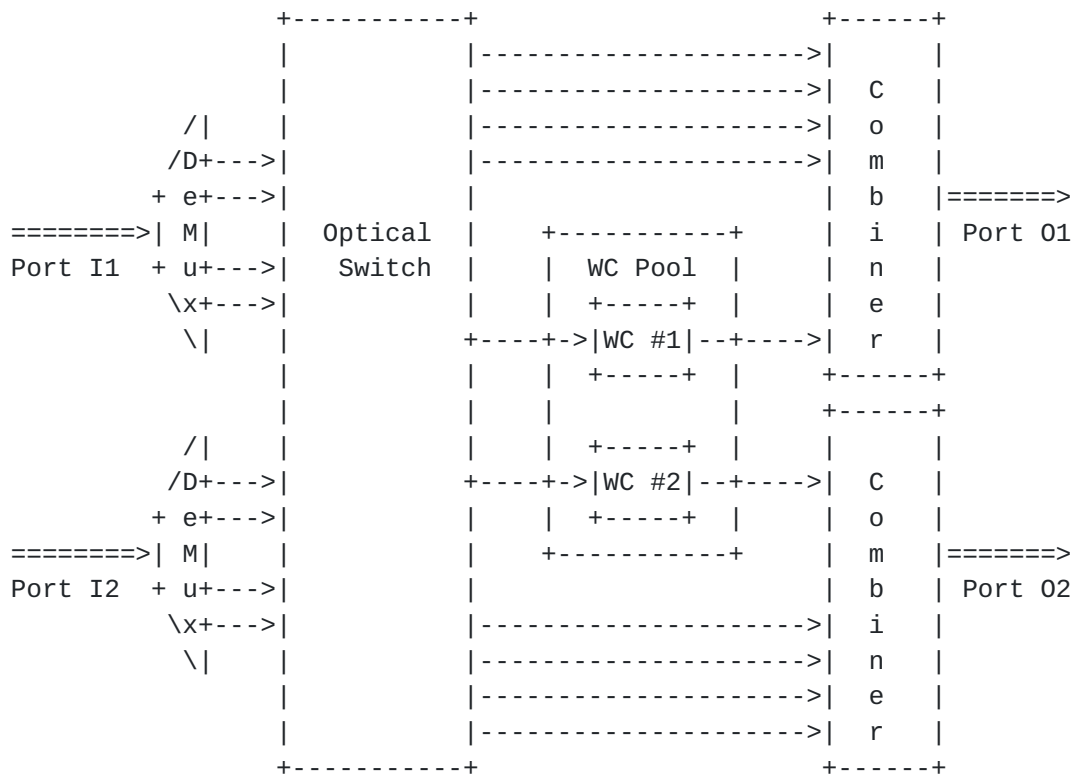


Figure 1 An optical switch featuring a shared per fiber wavelength converter pool architecture.

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
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|   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 01
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| 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 02
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Action=0    |1|   Reserved   |                               Length = 8           |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               Link Local Identifier = #2                          |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Action=0    |0|                               |                               Length = 8           |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               RB ID = #2                                         |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

A.2. Wavelength Conversion Range Field

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 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>
..]

```

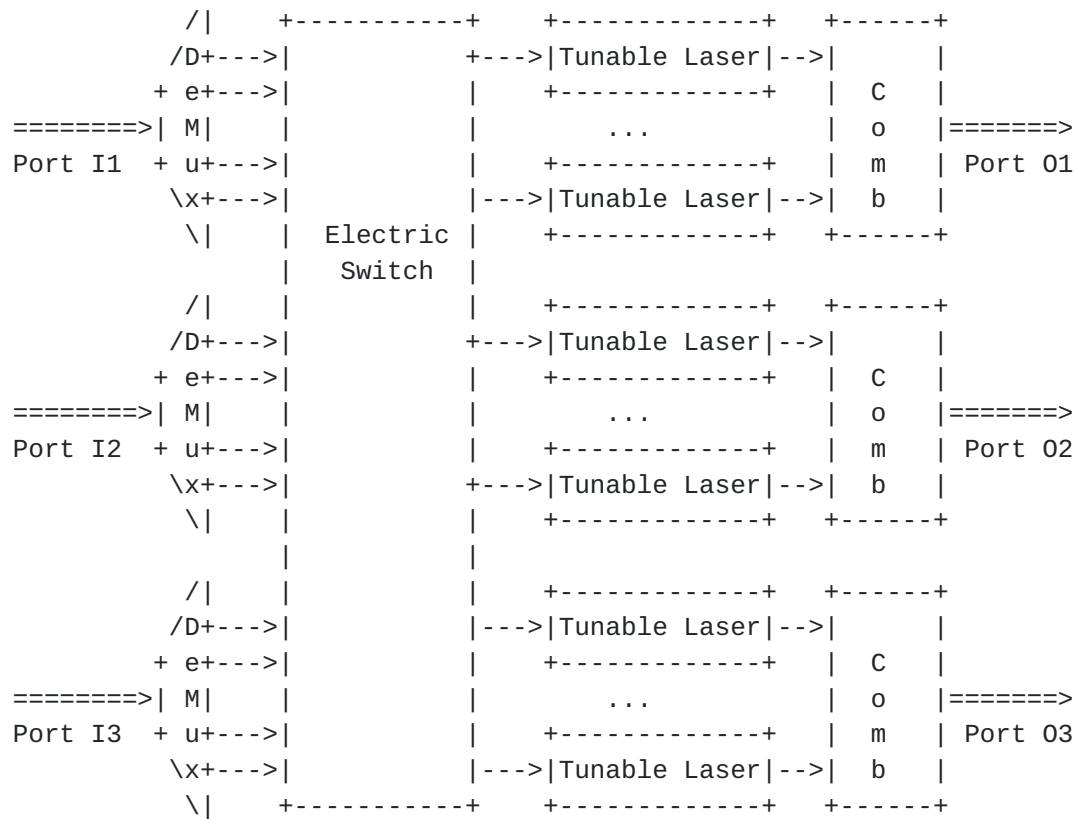



Figure 2 An optical switch built around an electronic switching fabric.

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)           |
| :                                                                           :
+-+-+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Input Client Signal Type                 |
| :   (G-PIDs for SDH and G.709)                                             :
+-+-+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     Input Bit Rate Range List                 |
| :   (2.5Gbps, 10Gbps)                                                       :
+-+-+-----+-----+-----+-----+-----+-----+-----+-----+
|                                     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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