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Information Model for Wavelength Switched Optical Networks (WSON) with Optical Impairments Validation.
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Abstract

This document defines the Information Model to support Impairment-Aware (IA) Routing an Wavelength Assignment (RWA) function. This operation might be required in Wavelength Switched Optical Networks (WSON) that already support RWA and the Information model defined here goes in addition and it is fully compatible with the already defined information model for WSON.

This information model shall support all control plane architectural options defined for WSON with impairment validation.

Status of this Memo

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1. Introduction

In the context of Wavelength Switched Optical Network (WSON), [RFC6163] defines the basic framework for a GMPLS control plane. The associated info model [I-D.ietf-ccamp-rwa-info] defines all parameters required for the related RWA process. These references are the foundation but they do not consider the Optical Impairment case.

In case of WSON where optical impairments plays a significant role, the framework document [RFC6566] defines related control plane architectural options for an Impairment Aware routing and wavelength assignment (IA-RWA). Options include different combinations of Impairment Validation (IV) and RWA functions through control plane elements and operations (PCE, Routing, Signaling).

This document provides the information model for the impairment aware case to allow the impairment validation function implemented in the control plane or enabled by control plane available information. This model goes in addition to [I-D.ietf-ccamp-rwa-info] and it is independent from any architectural option described by the framework [RFC6566]: it shall support all of them.

Computational Models for the optical impairments are defined by ITU standard body. The currently available computation models are reported in [ITU.G680] and only cover only the linear impairment case. This perfectly fit with scenario C defined in [RFC6566] section 4.1.1 and is considered in scope with WSON activity. The non-linear case is left for further study since currently no ITU computational models are available for an accurate optical impairment estimation.

The information model defined here provides a generic enough mechanism that could be easily extended to additional impairments models.

1.1. Requirements Language

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. Properties of an Impairment Information Model

An information model may have several attributes or properties that need to be defined for each optical parameter made available to the control plane. The properties will help to determine how the control

plane can deal with it depending on architectural options chosen within the overall impairment framework [RFC6566]. In some case properties value will help to identify the level of approximation supported by the IV process.

o Time Dependency.
  This will identify how the impairment may vary with time. There could be cases where there is no time dependency, while in other cases there may be need of impairment re- evaluation after a certain time. In this category, variations in impairments due to environmental factors such as those discussed in [G.sup47] are considered. In some cases a level of approximation will consider an impairment that has time dependency as constant. In this Information Model we do neglect this property.

o Wavelength Dependency.
  This property will identify if an impairment value can be considered as constant over all the wavelength spectrum of interest or if it has different values. Also in this case a detailed impairment evaluation might lead to consider the exact value while an approximation IV might take a constant value for all wavelengths. In this Information Model we consider both case: dependency / not dependency from a specific wavelengths. This property may appear directly in the Information model definitions or in the related encoding.

o Linearity.
  As impairments are representation of physical effects there are some that have a linear behavior while other are non-linear. Linear approximation is in scope of scenario C of [RFC6566]. During the impairment validation process, this property implies that the optical effect (or quantity) satisfy the superposition principle, thus a final result can be calculated by the sum of each component. The linearity implies the additivity of optical quantities considered during an Impairment Validation process. The non-linear effects in general does not satisfy this property. The information model presented in this document however, easily allow introduction of non-linear optical effects with a linear approximated contribution to the linear ones.

o Multi-Channel.
  There are cases where a channel's impairments take different values depending on the aside wavelengths already in place. In this case a dependency among different LSP is introduced and is typically a result of linear effects. This Information Model neglect this effects on neighbor LSPs.

The following table summarize the above considerations where in the

first column reports the list of properties to be considered for each optical parameters, while second column state if this property is taken into account or not by this Information Model.

Property	Info Model Awareness
Time Dependency	no
Wavelength Dependency	yes
Linearity	yes
Multi-channel	no

Table 1: Optical Impairment Properties

3. Background from WSON Information Model

In this section we report terms already defined for the WSON-RWA (not impairment aware) as in [I-D.ietf-ccamp-rwa-info] and [I-D.ietf-ccamp-general-constraint-encode]. The purpose is to provide essential information that will be reused or extended for the impairment case.

In particular [I-D.ietf-ccamp-rwa-info] defines the connectivity matrix as the follow:

```
ConnectivityMatrix ::= <MatrixID> <ConnType> <Matrix>
```

However according to [I-D.ietf-ccamp-general-constraint-encode] this definitions is further detailed as:

```
ConnectivityMatrix ::=
      <MatrixID> <ConnType> ((<LinkSet> <LinkSet>) ...)
```

This second formula highlights how the connectivity matrix is built by pairs of LinkSet objects identifying the internal node connectivity capability due to internal optical node constrain. It's essentially a binary information and tell us if a wavelengths or a set of wavelengths can go from an input port to an output port.

As a additional note, Connectivity Matrix belong to Node Information and is purely static. Dynamic information related to the actual usage of the connections are available through specific extension to

link information.

4. Optical Impairment Information Model

The idea behind this Information Model is to reuse the concept of the Connectivity Matrix and defines an Impairment Matrix that summarize optical impairments provided by the Node and Links (i.e. fibers).

The goal of this document is not to rephrase content from [ITU.G680] but only provide necessary building blocks that allow the IW-RWA process to apply the computational model defined by such recommendation. [ITU.G680] computational models defined in section 9 provide information to calculate the following optical parameters:

- OSNR. Section 9.1

- Chromatic Dispersion (CD). Section 9.2

- Polarization Mode Dispersion (PMD). Section 9.3

- Polarization Dependent Loss (PDL). Section 9.3

The recommendation [ITU.G680] call its computational model "transfer function" and details formulas for a set of different optical equipments. For the purpose of this information model, only the set of parameter is important.

This Information Model makes the assumption that the each Optical Node in the network is able to provide it's own contribution to above parameters. To this extent the Information Model intentionally ignore all internal detailed parameters that are used to by the formulas (i.e. "transfer function") but simply provide the object to carry results of the formulas. However no assumption is made on how the Optical node get the result of parameter contribution (e.g. computed, provisioned, known by design, etc.).

As an additional note, as reported in in [ITU.G680] Section 10, each parameter can be reported as an OSNR contribution, in such way the Optical Node not necessarily embed optical computational capability but can provide an approximated contribution to optical impairments.

With the above considerations this Information Model provides an abstract view for an optical node and link to enable WSON protocol extension with optical impairments validation.

4.1. Node Information

This model defines the Impairment Matrix as the following:

```
ImpairmentMatrix ::=  <MatrixID> <ConnType>
      ((<LinkSet> <LinkSet> <ImpairmemtVector>) ...)
```

Where:

MatrixID. Is a unique identifier for the Matrix. This ID shall be unique in scope among connectivity matrices defined in [I-D.ietf-ccamp-rwa-info] and impairment matrices defined here.

ConnType. This number identifies the type of matrix and it shall be unique in scope with other values defined by WSON documents.

LinkSet. Same object definition and usage as [I-D.ietf-ccamp-general-constraint-encode].

ImpairmentVector is defined as list of optical parameters associated to the internal node connection.

```
<ImpairmentVector> ::= [<LinkSet>] <OPTICAL_PARAM> ...
```

The optional LinkSet object enable wavelength dependency property as per Table 1.

OPTICAL_PARAM is an object representing an optical parameter. The Impairment vector contain a set of parameters as identified by [ITU.G697] since those parameters match the terms of the linear impairments computational models provided by [ITU.G680]. This information model does not speculate about set of parameters (since defined elsewhere, e.g. ITU-T), however it does not preclude extentions by adding new parameters.

The model can be represented as the multidimensional matrix shown in the following picture

```
                          _________________________________________
                         /        /       /       /       /       /|
                        /        /       /       /       /       / |
                       /________/_______/_______/_______/_______/  |
                      /        /       /       /       /       /| /|
                     /        /       /       /       /       / |  |
                    /________/_______/_______/_______/_______/  | /|
                   /        /       /       /       /       /| /|  |
                  /        /       /       /       /       / |  | /|
                 /________/_______/_______/_______/_______/  | /|  |
                /        /       /       /       /       /| /|  | /|
               /        /       /       /       /       / |  | /|  |
               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  | /|  | / PDL
   <LinkSet#1> |   -   |       |       |       |       | /|  | /|/
               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  | /|  /
   <linkSet#2> |       |   -   |       |       |       | /|  | / PND
               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  | /|/
   <linkSet#3> |       |       |   -   |       |       | /|  /
               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  | / Chr.Disp.
   <linkSet#4> |       |       |       |   -   |       | /|/
               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  /
   <linkSet#5> |       |       |       |       |   -   | / OSNR
               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                <LS#1>  <LS#2>  <LS#3>  <LS#4>  <LS#5>
```

The Connectivity Matrix from [I-D.ietf-ccamp-general-constraint-encode] only defines the two dimensional matrix, containining only binary information, through the LinkSet pairsa binary information. In this model a third dimension is added by generalizing the bnary information through the ImpairmentVector associated with each LinkSet pair. Optical parameter names in the picture are reported just as an example while detailed definitions will go into specific encoding drafts [I-D.martinelli-ccamp-wson-iv-encode].

This representation shows the most general case however, the total amount of information transported by control plane protocols can be greatly reduced by proper encoding when same set of values apply to all LinkSet pairs.

4.2. Link Information

The same approach used for the Node information can be used at Link Level. The Link information for WSON is extended in [I-D.ietf-ccamp-rwa-info]. This information model provide the following additional extension:

```
<DynamicLinkInfo> ::=  <LinkID> <AvailableLabels>
        [<SharedBackupLabels>] [<ImpairmentVector>]
```

DynamicLinkInfo is exactly the only already defined in [I-D.ietf-ccamp-rwa-info] while ImpairmentVector is defined in the previous section. Is considered as optional since apply as an extention to existing Link information.

In this case the list of contained optical parameters are associated to the link.

4.3. Path Information

In case of a control plane with impairment validation awareness there's might be cases where informations apply to the whole path and cannot be composed by individual contributions of links and nodes. The cases where this kind of information might be required are reported within [RFC6566] (Section 4.2.2 IV-Canditates or Sharing Constraints).

```
<PathInfo> ::=  <ImpairmentVector>
```

[EDITOR NOTE: section to be completed].

5. Encoding Considerations

Details about encoding will be defined in a separate document [I-D.martinelli-ccamp-wson-iv-encode] however worth remembering that, within [ITU.G697] Appending V, ITU already provides a guideline for encoding some optical parameters.

In particular [ITU.G697] indicates that each parameters shall be represented by a 32 bit floating point number.

As an additional consideration, actual values for parameters defined in the information models are provided by the Optical Node and it could provide by direct measurement or from some internal computation starting from indirect measurement. In any case the encoding shall provide an the possibility to associate a variance with the parameter. This information will enable the function implementing IV-RWA process to make some additional considerations on wavelength feasibility. [RFC6566] Section 4.1.3 reports some considerations regarding this degree of confidence during the impairment validation process.

6. Information model versus Control Plane Architectures

This section will briefly describe how the wholes set of informations defined by this info model will match the architectural options defined in [RFC6566]

The first assumption is that the RWA-WSON extentions are available and operationals. To such extent, the RWA-WSON will provide the following information through it's path computation (and RWA process):

- o The wavelenght connectivity (considering also the connectivity constrains by limited reconfigurable optics).
- o The interface compatibility at the physical level.
- o The Optical-Elettro-Optical (OEO) availability within the network (and releater physical interface compatibility as here above).

[EDITOR NOTE: to be completed]

7. Acknowledgements

TBD

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9. IANA Considerations

This document does not contain any IANA requirement

10. Security Considerations

All drafts are required to have a security considerations section. See RFC 3552 [RFC3552] for a guide.

11. References

11.1. Normative References

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Appendix A. G.680 Essential information

TBD if we need some info instead of reading [ITU.G680]

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