OPEN NETWORKING FOUNDATION

Core Information Model (CoreModel)

TR-512.A.4
Appendix – Analogue and Media Examples (Layer 0)

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Important note

This Technical Recommendations has been approved by the Project TST, but has not been approved by the ONF board. This Technical Recommendation is an update to a previously released TR specification, but it has been approved under the ONF publishing guidelines for 'Informational' publications that allow Project technical steering teams (TSTs) to authorize publication of Informational documents. The designation of '-info' at the end of the document ID also reflects that the project team (not the ONF board) approved this TR.

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Document History

Version	Date	Description of Change
		Appendix material was not published prior to Version 1.3
1.3	September 2017	Version 1.3 [Published via wiki only]
1.3.1	January 2018	Addition of text related to approval status.

1 Introduction

This document is an appendix of the addendum to the TR-512 ONF Core Information Model and forms part of the description of the ONF-CIM. For general overview material and references to the other parts refer to TR-512.1.

1.1 References

For a full list of references see TR-512.1.

1.2 Definitions

For a full list of definition see TR-512.1.

1.3 Conventions

See TR-512.1 for an explanation of:

- UML conventions
- Lifecycle Stereotypes
- Diagram symbol set

1.4 Viewing UML diagrams

Some of the UML diagrams are very dense. To view them either zoom (sometimes to 400%) or open the associated image file (and zoom appropriately) or open the corresponding UML diagram via Papyrus (for each figure with a UML diagram the UML model diagram name is provided under the figure or within the figure).

1.5 Understanding the figures

Figures showing fragments of the model using standard UML symbols and also figures illustrating application of the model are provided throughout this document. Many of the application-oriented figures also provide UML class diagrams for the corresponding model fragments (see TR-512.1 for diagram symbol sets). All UML diagrams depict a subset of the relationships between the classes, such as inheritance (i.e. specialization), association relationships (such as aggregation and composition), and conditional features or capabilities. Some UML diagrams also show further details of the individual classes, such as their attributes and the data types used by the attributes.

1.6 Appendix Overview

This document is part of the Appendix to TR-512. An overview of the Appendix is provided in TR-512.A.1.

2 Introduction to this Appendix document

This document provides various examples of the use of the CIM to model analogue and media structures

The examples in this document are built from descriptions other documents. The media examples are supported by a combination of the FC/LTP (as described in TR-512.2), the physical model (as described in TR-512.6) and the specification model (as described in TR-512.7).

Each case discussed in this document will be supported by FC specs, LTP specs and scheme specs. Most cases do not explicitly show the scheme spec but have been described using the base classes (FC, LTP etc) from which the scheme spec can be derived.

3 Optical Media

The network model required to support media is discussed in TR-512.2.

This document provides examples of usage of the network model to represent various photonic media functions and devices. For each example detailed stylized layouts of functions that are used to drive FD, FC, LTP and scheme spec are provided along with the resulting simple compact representation.

It is intended that sufficient stylized cases are covered here to allow a modeler to represent their specific function/device. It is not intended that all possible cases are covered.

The spec models provide detail to allow interpretation of the properties compacted into the simplified model and hence allow faults to be diagnosed. The figures in this document are essentially pictorial views of specs.

3.1 The basic components of the mode

3.1.1 The basic attenuator and filter

The following figure shows symbols for the basic attenuator and filter. Attenuators and filters are inherently omnidirectional.

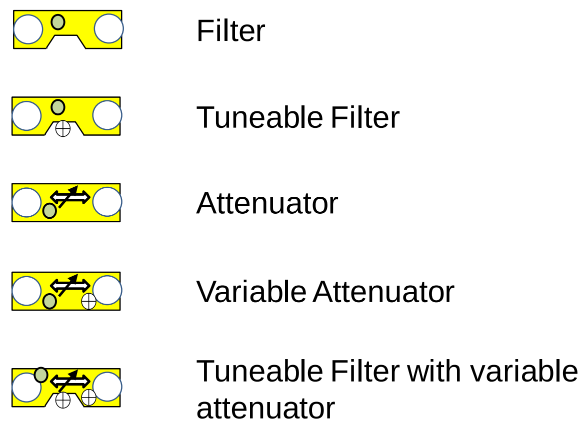

Figure 3-1 Attenuator and Filter (explaining the symbol set)

The filter models the ability to allow only those photons that are within in a defined portion of spectrum to be passed. The filter is described as a media channel and is represented by an FC.

The portion of the spectrum is called a frequency slot and is described by centre frequency and width. Frequency slot is an administrative concept and is conceptually square. The actual pass-band of the filter is not square. The frequency slot and pass band relationship is challenging and not covered here.

A single port of a filter can support more than one media channels (see later).

As the filter is represented by an FC the characteristics are expressed in an FcSpec (see TR-512.7).

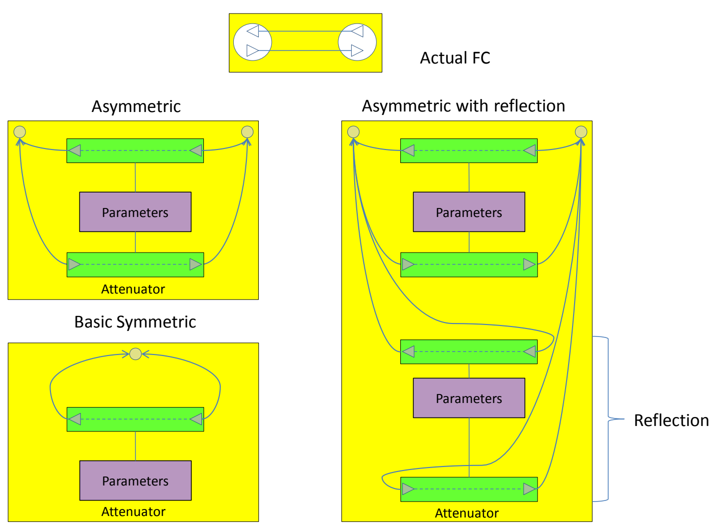

Figure 3-2 Pictorial view of example spec model for attenuator

The figure shows the two port FC along with three spec forms:

- Asymmetric: This allows the parameters for both directions of flow to be different. This is the easiest form to read and is recommended even when the device is symmetric
- Basic Symmetric: Appropriate where the device has exactly the same effect on both flows and there is no independent control of the flows. The current rule for an FcSpec of this form is that there is no flow from a port to itself so this does not readily allow reflection characteristics to be expressed (the FcSpec rule would need to become flexible per flow expression)
- Asymmetric with reflection: Shows a long hand form of the spec. Note that this is relatively verbose for a two port device. For a multi-port device, explicit expression seems particularly verbose and a more compact form of expression would be beneficial.

The parameter blocks in the spec provide invariant and adjustable values. Any aging characteristics could be stated in the parameter blocks.

For a complex filter with different characteristics per "band" the spec could either code the complexity in an expression or show separate "flows" (green) per "band". It is also possible to have a filter instance per "band".

The model (and symbol set) allows for a variable attenuator.

3.1.2 Coupler-Splitter

The following figure shows basic coupler/splitters. Coupler-splitters are inherently omnidirectional.

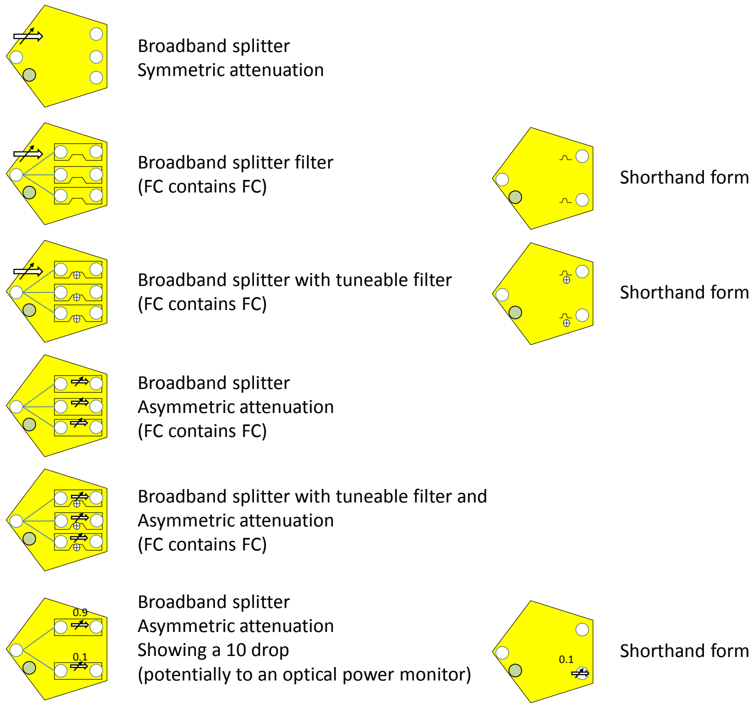

Figure 3-3 Coupler/Splitter

The Coupler/Splitter provides a set of atomic media channels between one (common) port and two or more other (branch) ports. All of these atomic media channels have the same frequency slot. In the root to leaf direction the "splitter" attenuates the signal, in the leaf to root direction the "coupler" has negligible attenuation.

3.1.3 The circulator

The circulator is a media component that takes advantage of non-linear characteristics to essentially provide a unidirectional flow. A circulator as shown in the figure below.

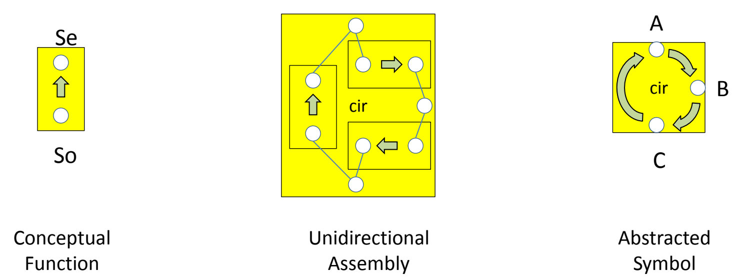

Figure 3-4 The circulator

In the circulator depicted, photons that arrive at FcPort A will emerge from FcPort B, photons that arrive at FcPort B will emerge at FcPort C and photons that arrive at FcPort C will emerge from FcPort A.

3.1.4 The photodiode

The photodiode is a media component that converts a photonic signal (in a frequency slot) to an electrical signal. Both the signal domain and the media change (the domain changes from photonic to electrical and the media from glass to copper (via various intermediate media))[1]. There is a media channel from the So to the converter (an adaptation) and a different media channel from the converter to the Se, however it is the domain change that is emphasized by the adapter symbol rather than the media change (as the physical layer is only modeled in abstract). The third symbol shows media transition. The assumption is that the FC is essentially electrical and the element that is not is exposed as an embedded FC with some fiber specification.

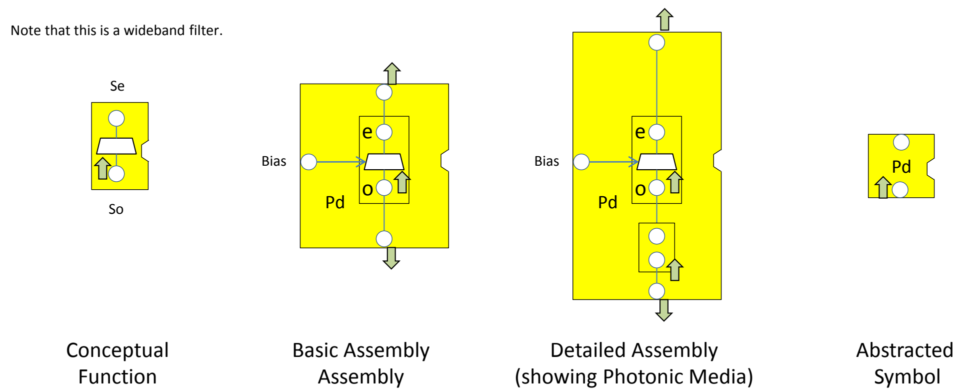

Figure 3-5 Photodiode as an active element (showing media)

The figure below shows the spec model for the Photodiode highlighting:

- The media specification
- The LTP spec representing the transformation from optical to electrical
- A specification of the reflection characteristics.

The bias signal is not supported at this stage.

[1] It was concluded that it was not helpful to indicate media change. The key information relates to domain change. In detail, there are at least four media here and probably more. Fiber to p-type to n-type to copper. This complexity does not add value.

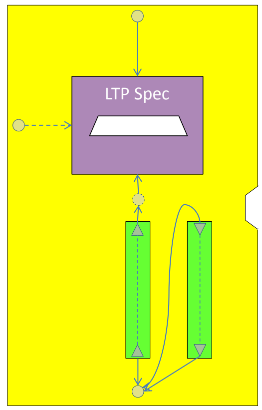

Figure 3-6 Pictorial view of example spec model for Photodiode

The figure below shows a photodiode in the context of an LP. The photodiode may be extract signal or may be used for power measurement. The optical power monitor measures the power of any optical signals that are present in a media channel.

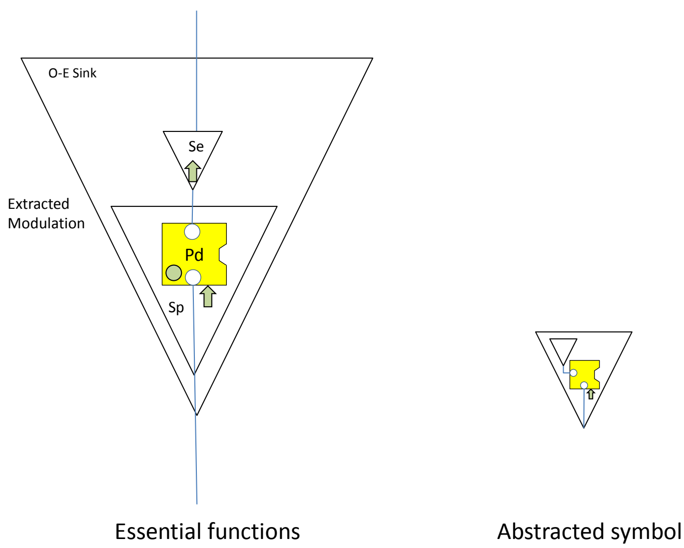

Figure 3-7 Photodiode as an active element showing power monitor

3.2 Complex assemblies

3.2.1 The Laser

The laser is a media component that takes advantage of non-linear characteristics to essentially convert an electrical signal to a photonic signal (in one frequency slot).

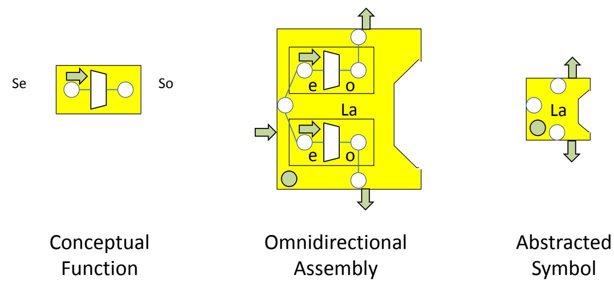

Figure 3-8 Laser as an active elements (showing media)

The lasing medium when stimulated with an electrical signal produces an equivalent photon signal. In the actual implementation the photons emerge at two facets. The "back" facet photon stream is used to measure the output of the laser. The measurement is fed to a control function that adjusts the electrical input to the laser.

The Laser with back diode is shown in the context of the E-O Source LP.

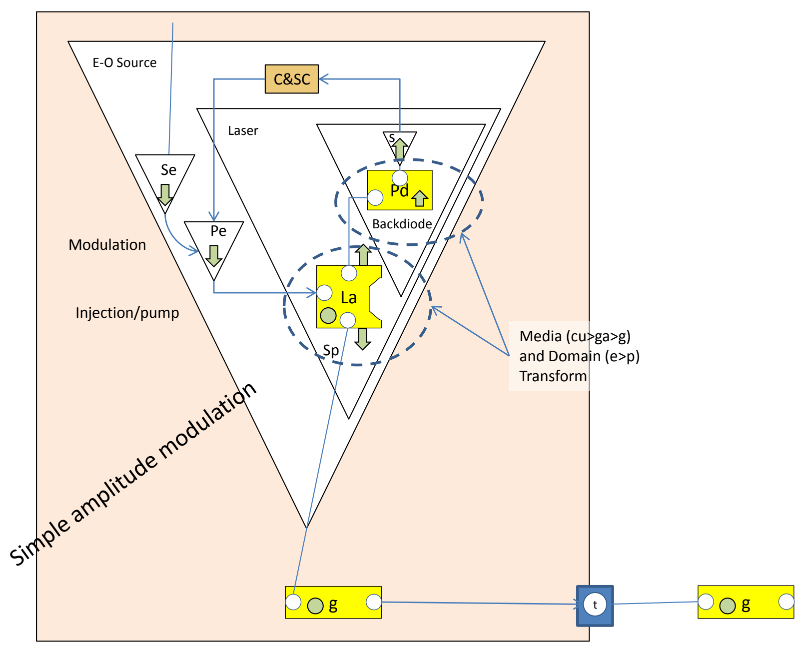

Figure 3-9 Laser as an active element (showing media)

The spec for the E-O Source explains the arrangement of functions and provides a mapping to the E-O LP instance and content. From the figure it can be seen that the LP includes two Terminations an adapter, two FCs and a C&SC. The two FCs can be merged and the spec for the LP then looks as in the figure below.

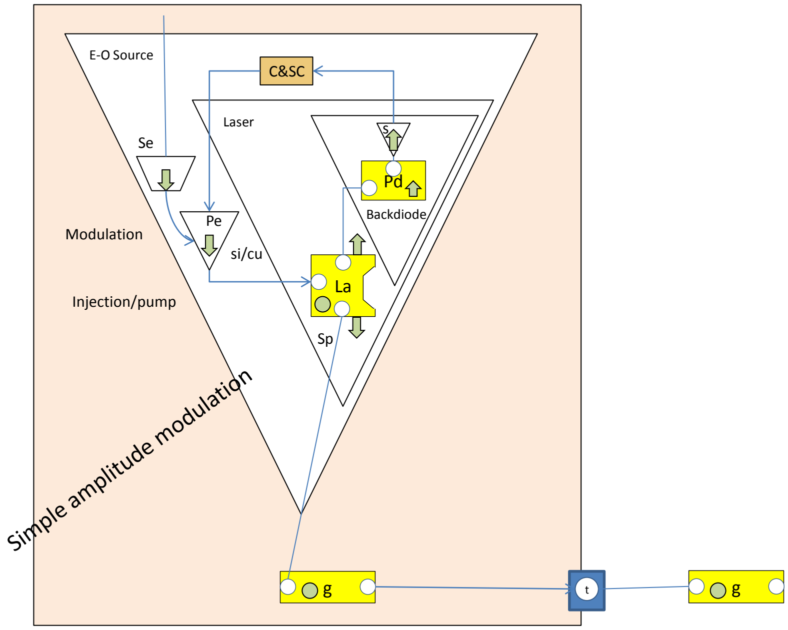

Figure 3-10 Spec for Laser

A compact view of the media E-O LP is shown in the diagram below[2].

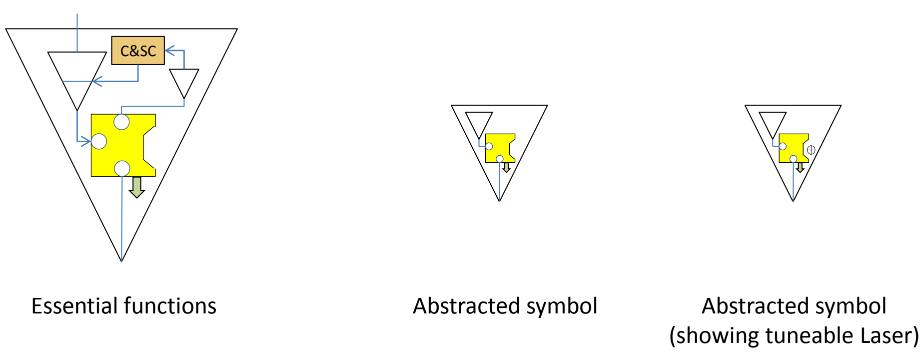

Figure 3-11 Essential functions of a laser and abstracted symbol for a laser

An alternative construction of a photonic transmitter is shown in the figure below. In this case, rather than an output that is amplitude modulated with the signal, the output is phase modulated or amplitude modulated (or both) by an external device. In this case the electrical signal carrying

[2] The structures shown here and throughout this document need to be described in LTP and FC specs (see TR-512.7). The actual spec forms will be developed in the next release.

the information is applied to the external modulator and the laser produces a constant power output.

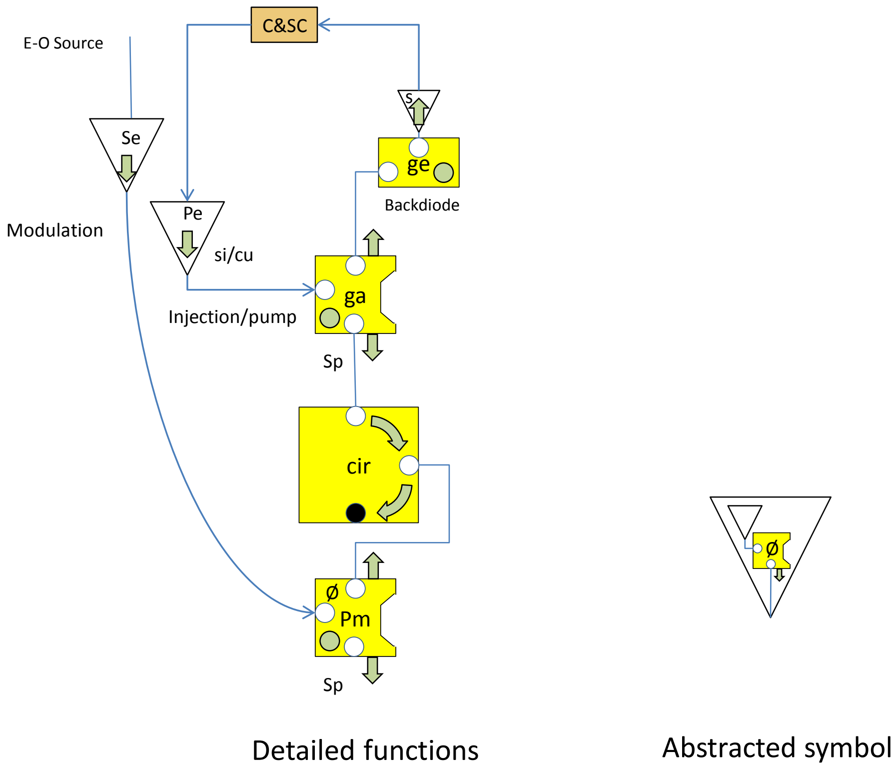

Figure 3-12 Sketch of phase modulated output

3.2.2 The coherent receiver

The figure below shows the simplified view of a coherent receiver with digital signal processing (DSP)[3]. A coherent receiver uses a heterodyne detector to convert the information carried by the photons into a "baseband" electrical signal that is then processed by DSP to correct for impairments introduced by the network domain channel. The abstracted symbol encapsulates the frequency tuning aspects and the DSP in the FC but separates out a termination to deal with the optical to electrical conversion. The symbol is not an accurate depiction of the actual processing but it allows for a more consistent representation from a management-control perspective.

[3] This model will potentially need enhancement when SD FEC (Soft Decision Forward Error Correction) is included.

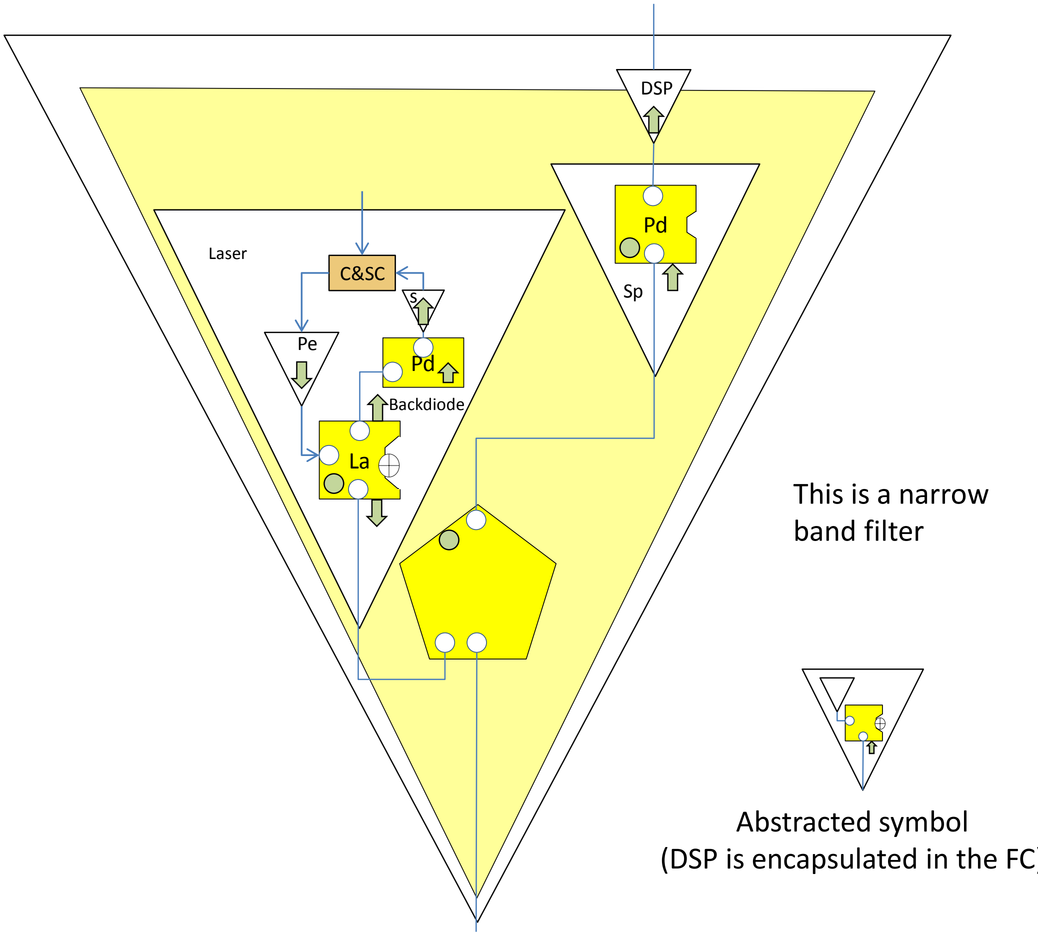

Figure 3-13 Coherent receiver assembly with simplified symbol

3.3 Network considerations

This section provides views of the basic elements described in the previous section combined into network constructs.

3.3.1 The Media Channel and Information Transfer

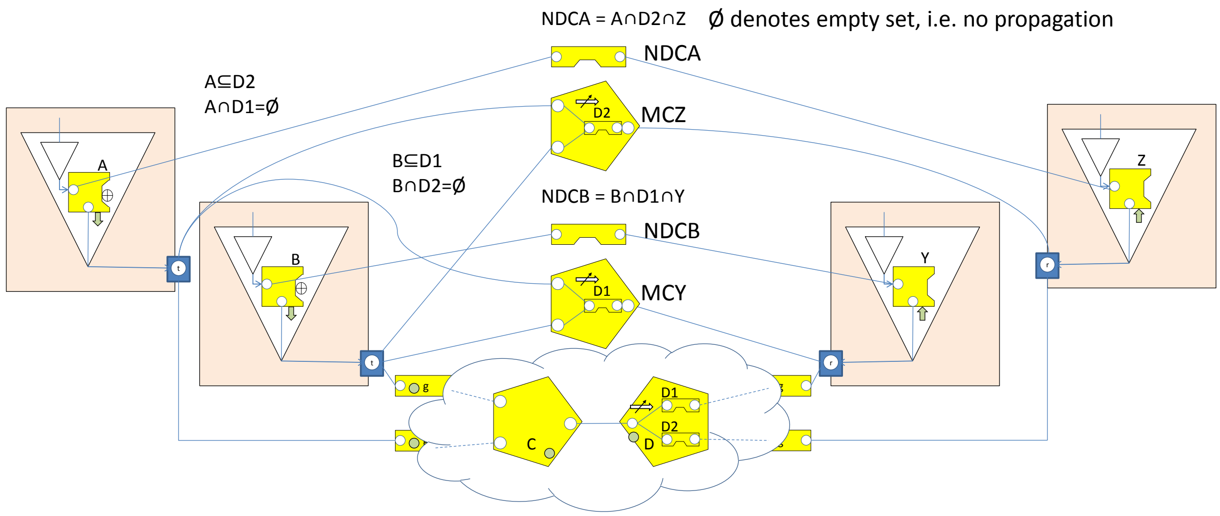

Figure 3-14 Network Domain Channel formed from Media Channels

In this document the Network Domain Channel (the FCs NDCA and NDCB) is considered as being from the point of injection of electrons into the laser medium or external modulator to the point of emergence of electrons from the photodiode[4]. The NDCs shown are formed as a result of the effects of the filters in the coupler C and splitter D which are reflected in the Media Channels MCY and MCZ (both of which are FCs with three FcPorts). It is not until the lasers A and B are applied to the MCY and MCZ that the effective NDCs can be determined. In the figure, Y and Z are wide band receivers. If A and B were tuned such that A⊆D1 (and hence A⋂D2=Ø) and B⊆D2(and hence B⋂D1=Ø) then NDCA would go from A to Y and NDCB from B to Z.

The figure below shows a basic consideration of information transfer. For the broad band receiver the information transfer capability is dictated by the NDC.

[4] Network Domain Channel is used in this document to define the "end to end" span of potentially mixed media that can carry a signal of a particular domain. For example it is defined from the point at which electrons are converted to (modulated) photons to the point where the information carried by the photons is converted to electrons. The term Network Media Channel is not used in this document. An NMC is an MC that spans from the output of a laser to the input of a photo diode. It is potentially mixed media. The MCY and MCZ in the diagram are essentially Network Media Channels. This designation is not helpful in understanding the model or the application.

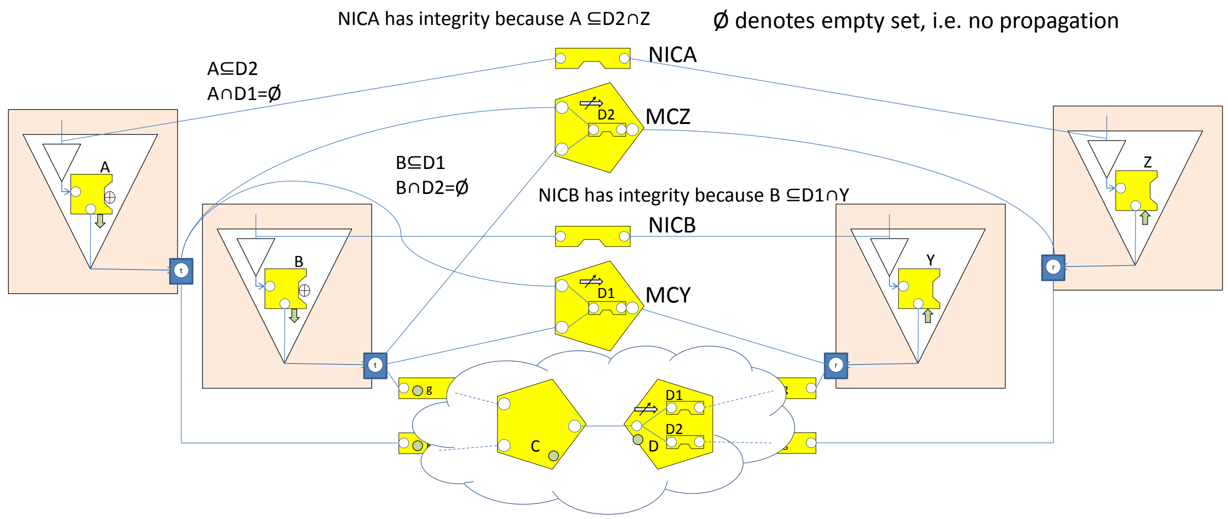

Figure 3-15 Information Transfer Channel formed from Media Channels for broadband receiver

The figure below shows MCZ and MCY are transparent. The ability to transfer information is dictated by setting of the tunabe laser, the setting of the hetrodyne detector and the capabilities of the receiver DSP. The figure provides a somewhat simplified representation of the information transfer capability.

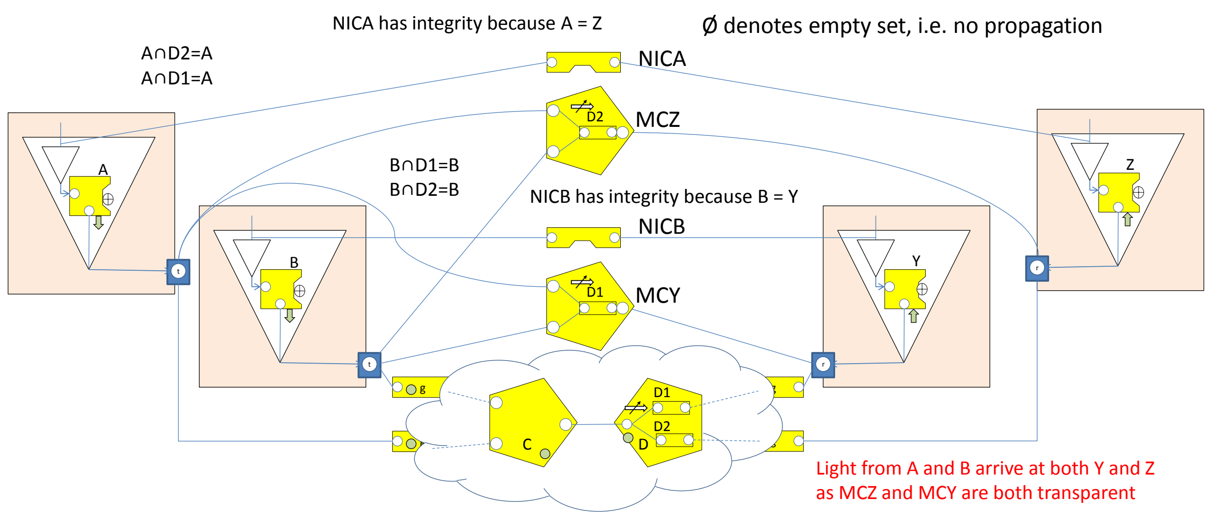

Figure 3-16 Information Transfer Channel formed from Media Channels for coherent receiver

3.3.2 The amplifier

Amplification is achieved using non-linear characteristics of fiber. The optical amplifier acts on a band of frequencies to increase the optical power level.

3.3.2.1 General considerations

The abstract symbol for an amplifier element is shown in the figure below.

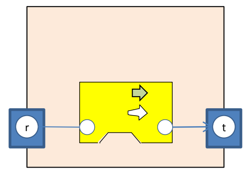

Figure 3-17 Abstract symbol for an amplifier

The abstract symbol can be used to represent an amplifier where a detailed consideration is not relevant. In a simplified view the gain parameters are parameters of the FC and the input and output power measures are parameters of the FcPorts. The spec model set provides the mapping from the parameters in the simplified view and the detailed interpretable view.

Where the amplifier provides different amplification for different bands/slots a number of instances of the symbol can be used as shown below. Where control/monitoring is relevant parameters can be offered on a per amplifier FC or FcPort basis as appropriate.

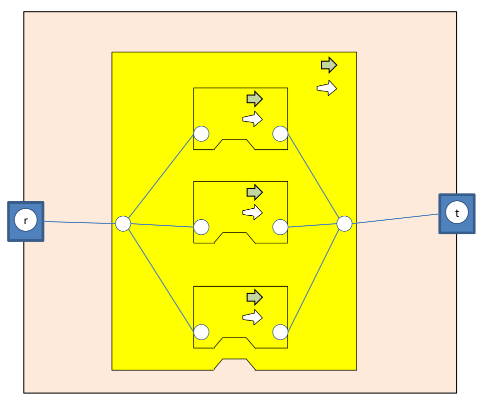

Figure 3-18 Abstract Symbol for a multi-band/slot amplifier

For more complex cases a more detailed model will be required. The following sections detail different application methods.

3.3.2.2 Erbium Doped Fiber Amplifier (EDFA)

This amplifier uses a short length of fiber doped with Erbium as the non-linear element that is fed at one or more points by pump lasers of specific wavelengths. This combination causes power transfer to a set of signal wavelengths that arrive at the input side of the amplifier. The EDFA is unidirectional.

The following figure shows a stylized view of an EDFA with one forward (co-directional) pump laser and fragment of control (including measurement of one band of incoming/outgoing signal only). In a full form, many bands may be measured, there may be many pumps in an amplifier and there may be two or more amplifiers in parallel amplifying different bands (e.g. L band and C band[5]).

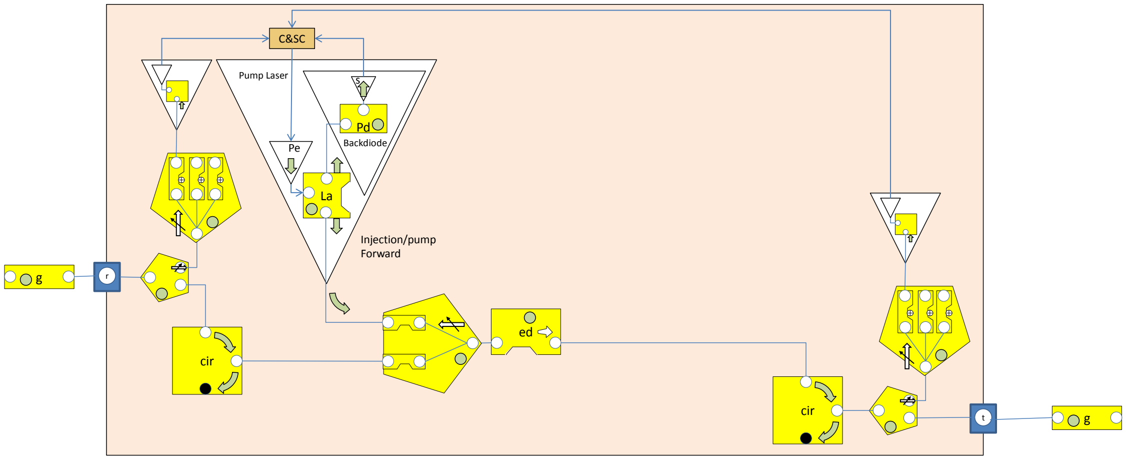

Figure 3-19 A stylized view of a fragment of an EDFA

The essential function of the amplifier is to provide balanced amplification to all relevant incoming signals. To enable interpretation of the measures and adjustment of the controls a suitably detailed spec model should be provided. The spec model should show necessary detail such that the effects of each control and the meaning of each measure can be interpreted. Certain elements of the EDFA (such as the circulators) are not relevant from this perspective. The spec may represent the amplifier as a set of parallel per band amplifiers from this perspective.

Considering fault analysis, it may be necessary to represent the amplifier in more precise detail especially where the amplifier is constructed from a number of separate field replaceable units.

It is likely that several related spec models will be necessary in the most complex case[6].

The following figure shows a fragment of a model of an EDFA with a backward pump.

[5] See https://en.wikipedia.org/wiki/Wavelength-division_multiplexing

[6] Sufficient detail is required in the spec of the amplifier to allow interpretation of the detected conditions. The detail will in part depend upon the FRU structure of the amplifier. The model approach is intended to be suitable for use by the controller that interfaces directly to the optical components, i.e. where there is no lower level controller abstraction and/or analyzing/interpreting the detectors.

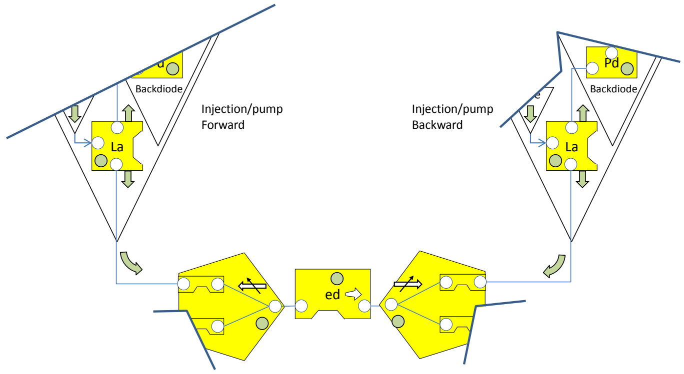

Figure 3-20 A further fragment of an EDFA with a forward and a backward pump

3.3.3 Amplification using the Raman effect

The following figure shows a stylized view of a Raman amplifier. The amplifier uses the main transmission fiber as the amplification element. Various other filters and monitors may be present in full representation.

As for the EDFA there may be a need for several related spec models to provide views for different purposes.

A simplified view may use the amplifier symbol in the figure above or amplification can be shown on the FC for the transmission fiber (as in the figure below).

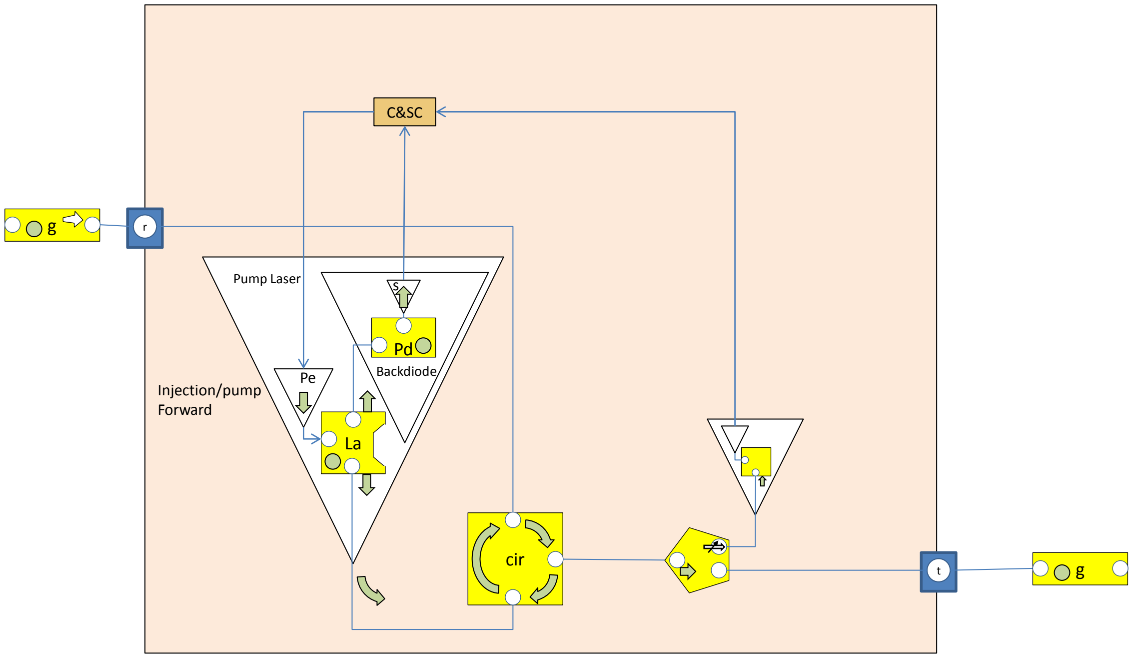

Figure 3-21 Stylized model view of a Raman amplifier

3.3.4 OMS and OTS

This section deals with the monitoring of sections of a photonic network. The model is derived from representations in [ITU-T G.872]. The following figure shows a fragment of topology positioning the OMS and OTS with respect the photonic and electronic components.

The figure includes three diagrams. The detailed view shows a layout of components (each component view is itself simplified). The measures in the detailed view can be projected to the corresponding points in the simplified view. A set of scheme spec would explain the relationship between the simplified view and the detailed view (and clearly further spec would explain the measures on each component in terms of further detail).

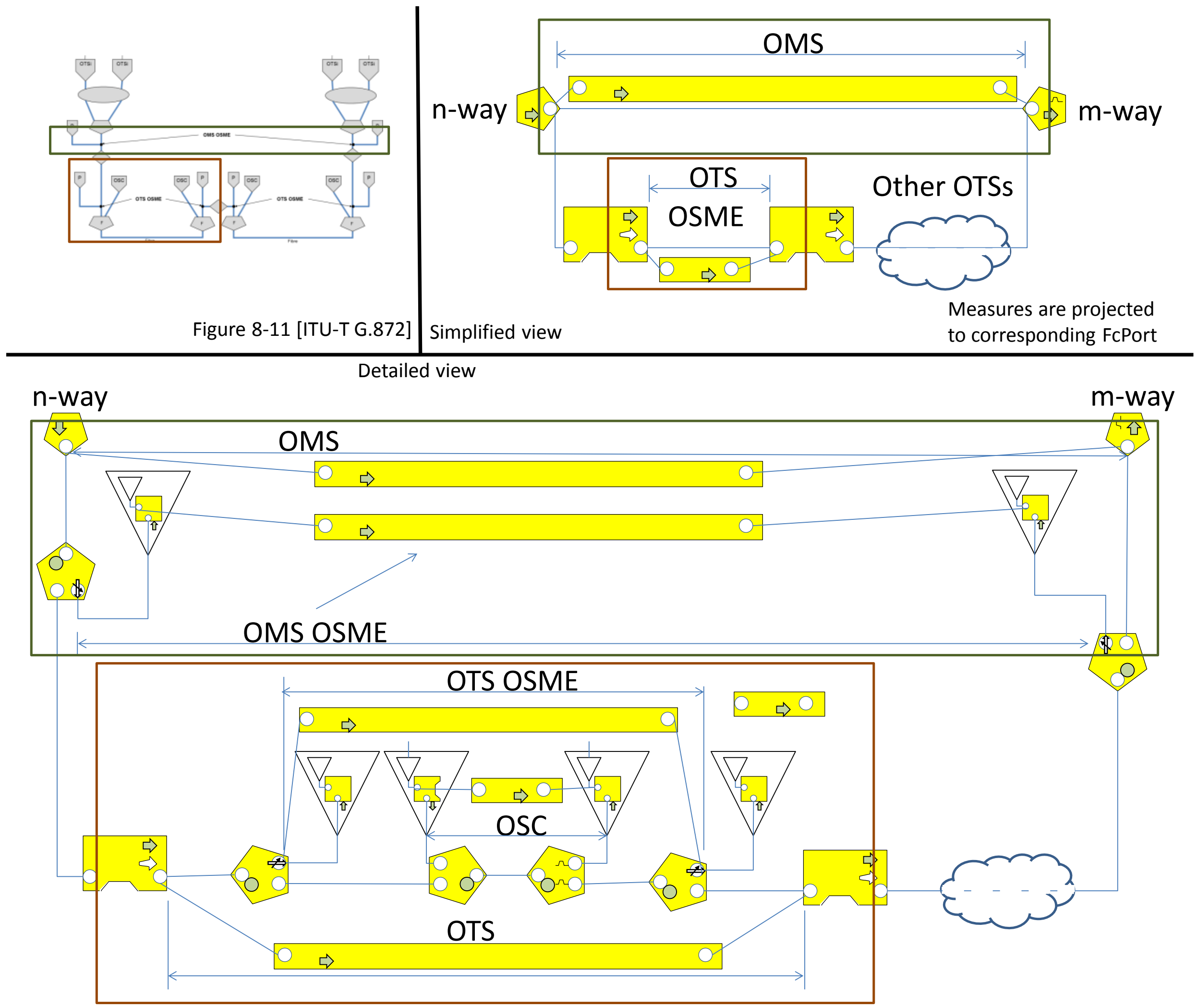

Figure 3-22 Topology fragment showing OTS in detail and OMS in abstract (assuming EDFA)

The OMS information is conveyed via the OSC. The OSC terminates for each OTS span and hence the OMS information needs to be propagated between OSCs at the points of OTS termination. This detail is not shown but would be explicitly modeled in the relevant specs (essentially simple forwarding). Bidirectional considerations of the OMS, OTS and OSC are not covered here.

Note that the OTS monitors shown in the figure above will probably be the monitors of the amplifier itself and hence the OTS OSME will extend between the output port and the input of the amplifiers as show in the simplified view such that the OTS and OTS OSME become coincident.

The OTS, OTS OSME, OMS and OMS OSME are represented by FCs. OTS FC is between the output of one amplifier and the input of the next. The OMS FC is between a point of aggregation and a point of disaggregation.

The Optical Supervisory Channel is essentially an NDC and is represented by an FC.

3.3.5 OTSi in context of OTU, OMS-O and OTS-O

The following figure provides a detailed view of the representation of the LTPs and FCs that represent OTU mapping onto media.

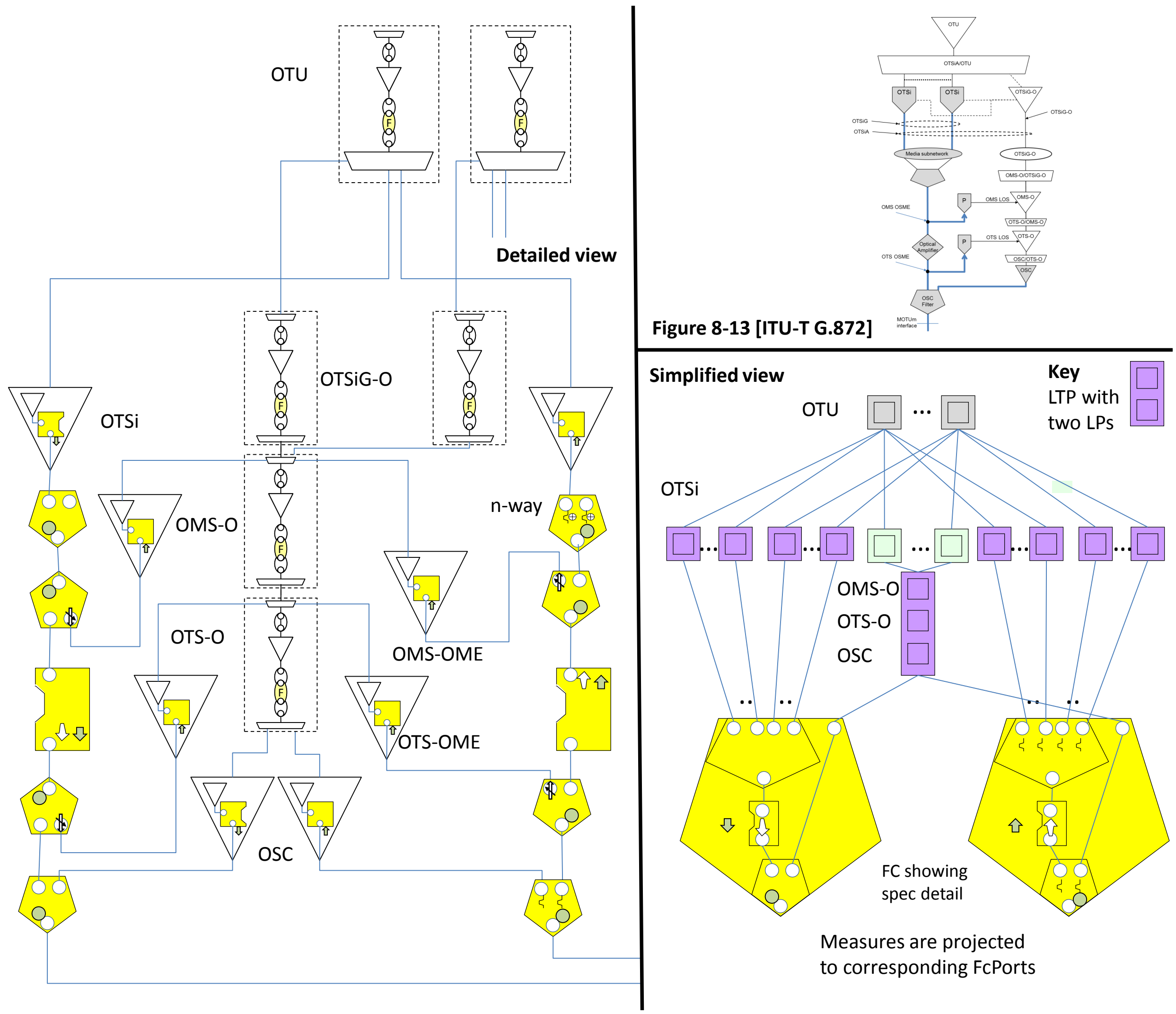

Figure 3-23 OTSi in context of OUT, OMS and OTS

An OTU is supported by a set of one or more OTSi (Optical Tributary Signal)

The set of OTSis that carry a single OTU are considered as a group (OTSiG) from a management-control perspective. The OTSi is characterized by the central frequency and an application identifier. Each OTSi is carried in an independent NDC. The differential delay between members of the OTSiG must be controlled.

If the OTSiG O is used then all members of the OTSiG and the OSC that carries the OTSiG O are carried over the same fiber.

The OSC is an OTSi that is used to carry the OTSiG O and a Data Communications Channel

3.4 The Field Replaceable Unit (FRU) and the Media Element (ME)

Each functional component discussed up to this point do not necessarily equate to an FRU. It is often the case that a function will be supported by several FRUs and also that several functions will be supported by a single FRU. From a maintenance perspective,, the FRU is the relevant construct. The FRU is modeled as a Replaceable Equipment.

The following figured depict Media Elements (MEs). It is assumed that MEs equate to Field Replaceable Assemblies of one or more FRUs[7].

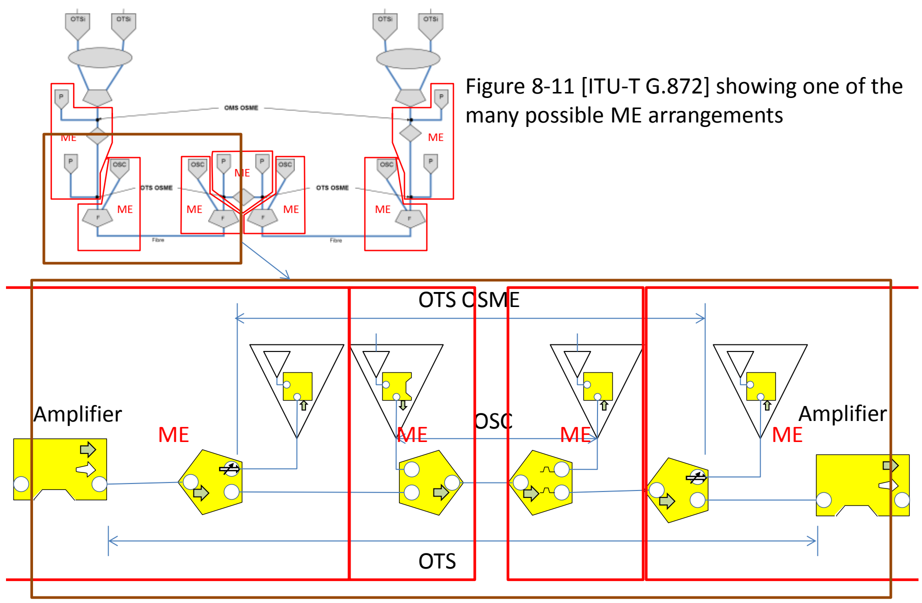

Figure 3-24 One of the many possible ME arrangements

The Raman amplifier case would have a similar arrangement to the figure above recognizing that again that the receive side monitors will probably be those of the amplifier itself and that in the case of Raman the amplifier is the fiber.

The figure below shows other possible arrangements of MEs (recognizing that the upper diagram is probably unlikely as the monitor is likely to be part of the amplifier as discussed earlier).

[7] An ME larger than an FRU is not ideal as the FRU is the key granularity for field replacement. If an ME is deemed to have failed all FRUs that it is built from will need to be replaced. The ME appears to not include the control functionality. This is not a useful management/control construct.

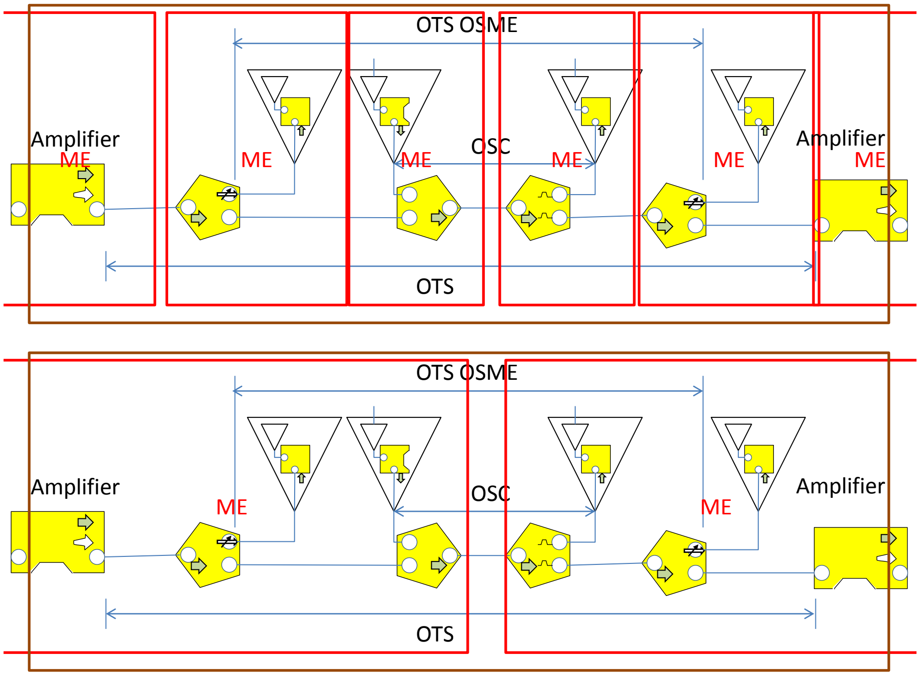

Figure 3-25 Two other possible ME arrangements

The ME

- Encompasses one or more media constructs.
- Can encompass one or more MEs[8].
- Has one or more ports
- Has zero or more interfaces for management
- May be opaque such that the internal structure is not visible BUT
  - Clearly there are parameters that will be positioned against the inputs, the function or the outputs
  - The spec structure should explain sufficient of the structure to allow suitable interpretation of the reported information and controls.
- Is described in most cases as one of more FCs[9]

An example media element is a reconfigurable add-drop.[10]

[8] For normal maintenance physical ports must be visible on the FRUs. The recursive ME not remove the need for full visibility of FRUs.
[9] Back to back FCs can be used were there is no exposed physical boundary. An FD or CD will be necessary to bound MEs where the ME boundary is not coincident with a physical port. BUT if not coincident with a physical port it is not clear how the ME can be useful wrt field replaceability. The opaqueness may also make the ME not useful.
[10] This appears to be too large a unit for useful management/control.

4 For further study

4.1 Photonic and Media parameters

The normative source of media parameters will be chosen (ITU-T), the model from that source will be Pruned and Refactored as appropriate and the parameters will be assembled in example spec models. The parameters will be mainly represented in LtpSpecs[11]. All parameters will be available and a selection can be made by the vendor etc.

The spec provides interrelationship rules between the parameters.

4.2 Considering G.872

- Media port
  - Media construct/element boundary
  - Media Port: *a logical abstraction that represents the ends of a media channel, the boundary of a media construct or the boundary of a media element*

  Comment: This appear to be somewhat jumbled. Coherent places appear to be the FcPort, the LTP and the Pin. It seems that MediaPort blurs this.

- Media channel – represented by the FC
  - Media Channel (MC) (see Figure 8-1): *represents both the path through the media and the resource (frequency slot) that it occupies.*
  - "Atomic" MC: It is a MC at bottom of MC-decomposition in the context of a particular view
  - Network Media Channel (NMC) – output of a modulator to input of demodulator[12]
- Media Link – represented by the FC
  - Pure topological relationship
  - One or more media channels[13]
  - Media Link: *represents path through the media*

  Comment: An example of a media link is a uni-directional OMS that uses C-band and L-band amplifiers. The C-band and L-band are represented each represented as media channels (with the same end points each with its own frequency slot. There is some

[11] Note that for management purposes some "parasitic" parameters e.g reverse loss in an isolator may not need to be represented.
[12] As noted earlier the NMC is not a useful concept.
[13] A media channel has a contiguous spectrum. A media link can represent a set of one or more media channels where the spectrum is not contiguous. An example of this is a media link that represents a chain of c-band and l-band amplifiers. This would have two media channels and the spectrum “between” the c-band and l-band media channels is not supported by a media channel.

"dead" or unusable spectrum between these frequency slots and hence the combination of these two media channels does not result in a single media channel. A bidirectional media link may also be used to represent a pair of (counter directional) unidirectional OMS media links. In the case where the OMS uses both C-band and L-band amplifiers it would represent four unidirectional media channels.

- Media Subnetwork
  - Flexible connectivity
  - Media Subnetwork: *a topological construct that represents a point of flexibility where the associations (represented by media channels) between the media ports of the media subnetwork may be created or deleted*

  Comment: Provides constraints to indicate which MCs can be created by control action. BUT probably best represented as FC in FC rather than FD for some cases but as FD for the case where, for example a subnetwork or flexible grid capable filter, had no contained FCs i.e. no enabled forwarding. Since media subnetworks typically have some (load dependent) blocking normally a FC spec is used to describe these constraints.

4.3 Other technology considerations

This section lists other relevant considerations that will be accounted for in future releases:

- Implications of the Media model for Wireless
- Raman OTS/OMS.
- The media element
  - The ME is not simply an FD although the FD is useful in grouping aspects of capability.
  - The boundaries do not look coherent (with Raman, there is no hard end to the amplifier). In some cases it is LTP in others it is some multi-LTP construct
  - Question about the Media Element grouping. The groupings do not look useful from a maintenance/control perspective.
  - Why is the electrical monitoring stack and the corresponding media stuff not grouped? This is more like a normal TTP and then LTP
- FcSpec: frequency (mandatory; m,n 12.5 step, 25 width; SG15 G.694.1), transfer characteristic, etc.
- G.694.1 uses the (m,n) schema. There may be other standards schema and proprietary schema.
- Use identifiers to identify the frequency specification schemas.
- OMS Media Channel could be shared by multiple Media Channel
- Picture using FC for network media channel without power but yet have OMS etc. available.

4.4 Other Pictorial cases

This section includes a number of cases from ITU-T G.872.

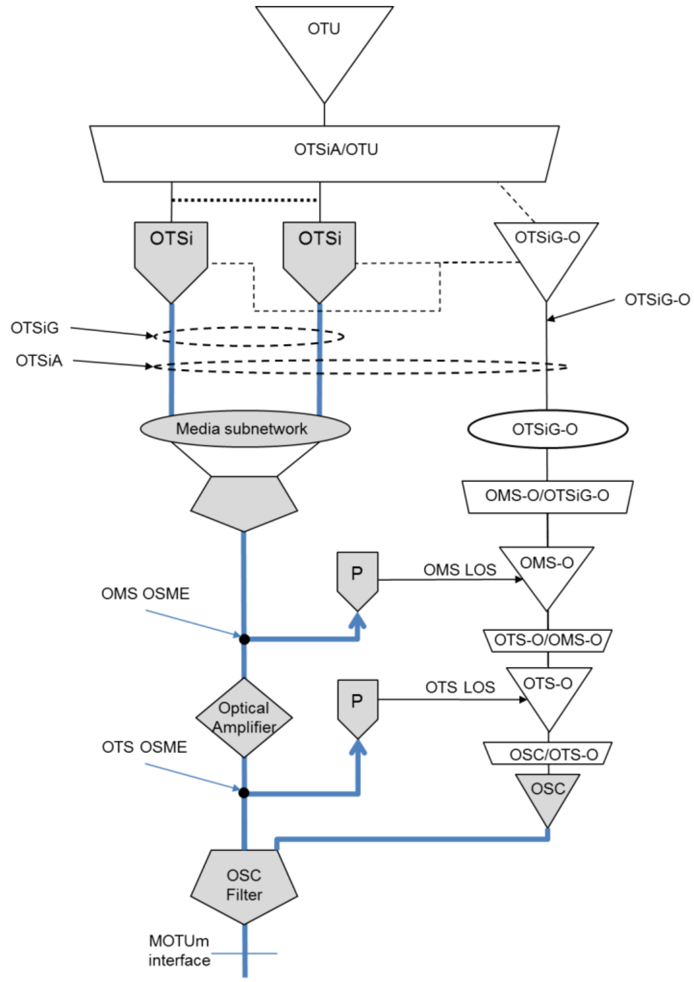

Figure 4-1 Copy of Figure 8-13 from [ITU-T G.872]

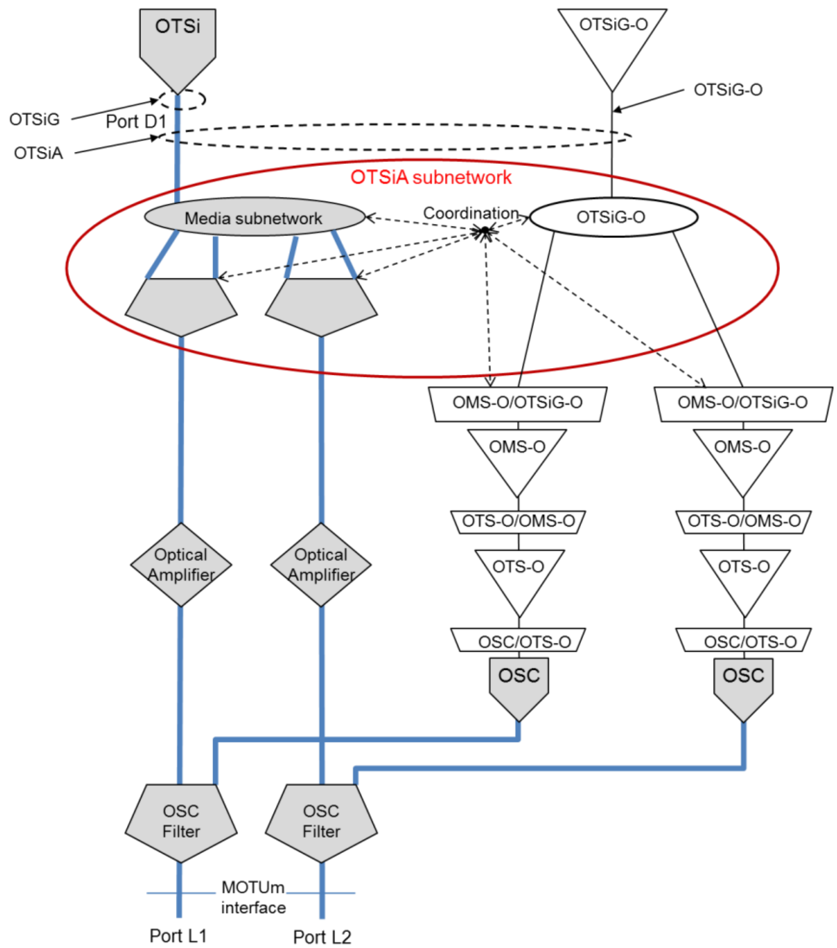

Figure 4-2 Copy of Figure 8-15 from [ITU-T G.872]

It is assumed that the "NE" carries out the coordination identified e.g. for managing an OTU connection. But for some applications e.g. inventory, fault management an "external" system needs to understand the relationships. This needs to be verified.

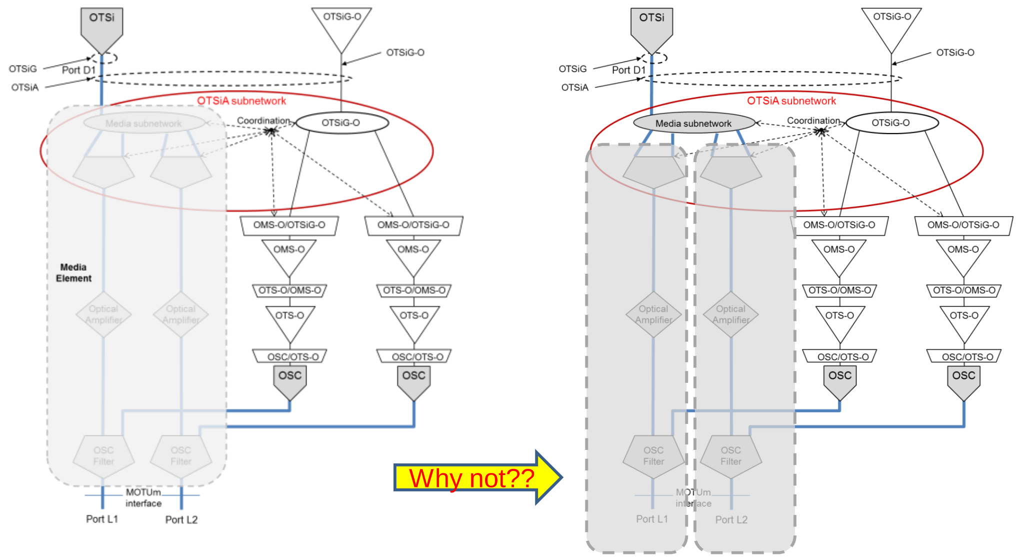

Figure 4-3 Copy of Figure 8-16 from [ITU-T G.872] (on left) with basic proposal (on right)

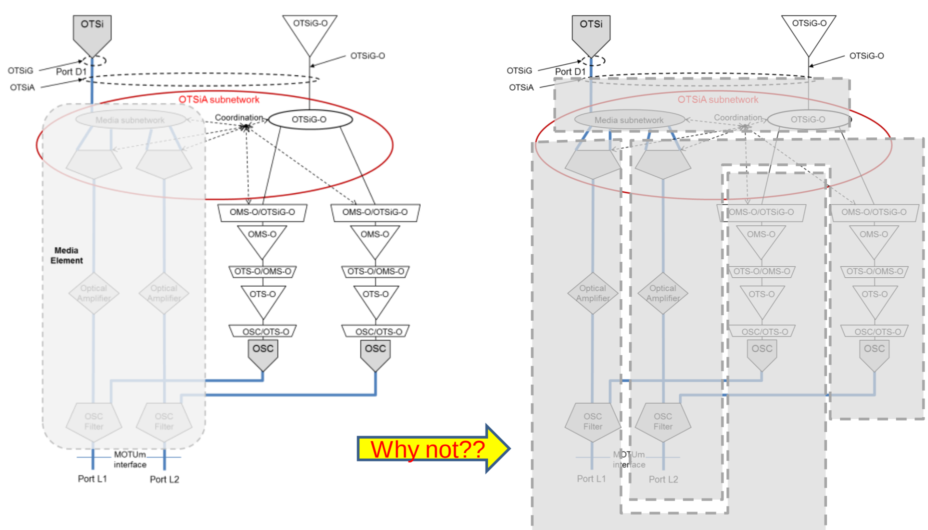

Figure 4-4 Copy of Figure 8-16 from [ITU-T G.872] (on left) with enhanced proposal (on right)

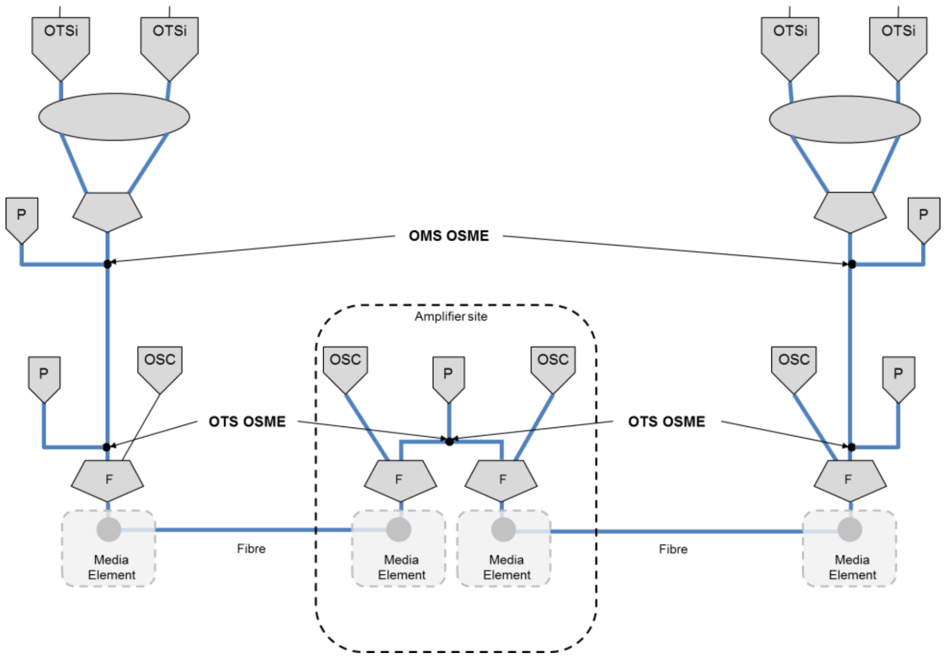

Figure 4-5 Copy of Figure 8-12 from [ITU-T G.872]

Need to extend model to show Raman.

End of Document

