FUNCTIONAL MODELLING CONCEPTS

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1 PURPOSE AND SCOPE

This text provides a description of several unique aspects of TeleManagement Forum (TMF)'s **MTNM (Multi-Technology Network Management)** NML-EML interface and **MTOSI (Multi-Technology OS Interface)** OS-OS interface, in particular the protocol-neutral object modelling concepts. It has been written with a number of key purposes in mind and is aimed at several distinct reader groups:

- developers of the EML and NML roles of the MTNM and MTOSI interface to help them gain a common understanding of the kind of data that may be received over the interface and the meaning of the data
- ITU-T members and those familiar with recommendations related to ITU-T G.805 (see Annex Introduction to G.805) to both demonstrate the alignment with the work in ITU-T and also to show applications of the G.805 model extended through MTNM to real network situations

The text provides several perspectives to cater for readers who are familiar with network element (NE) hardware but not familiar with the ITU-T recommendations as well as readers familiar with ITU-T G.805 but not so familiar with the restrictions and capabilities of real hardware.

It is not intended to be a specification of requirements, rather more a descriptive text of modelling recommendations to aid the understanding of the interface definition.

The novel pictorial form of the model components may be used by the vendor or purchaser to aid the description of a model of any specific port or set of interconnectable ports in any of their equipment to be managed via MTNM and MTOSI. To that end a set of power point component parts have also been included in a separate supporting document SD1-22_modelDiagramComponents.pdf for extraction and assembly.

The term “MTNM model” will be used in this document when referring to the model used by both MTNM and MTOSI and the term “MTNM interface” will be used in this document when referring to both the MTNM and MTOSI interfaces.

2 INTRODUCTION

The MTNM model promoted by the TMF has been developed by considering:

- the transmission technology capabilities of real network elements deployed today (SDH, SONET, OTN/WDM, ATM, DSL, Ethernet, Frame Relay, inverse multiplexing, etc); refer to the supporting document SD1-17_LayerRates.pdf for a list of technologies, expressed as characteristic information (CI) or adapted information (AI) of transmission layers, supported by this version of the interface
- the evolution of networks and network elements in many technologies (e.g., Ethernet and Services with customer separation, AAL, Circuit Emulation over ATM or Ethernet (including SDT mode), MPLS, IP Services, ASTN/ASON and GMPLS, VoATM/VoDSL, Provider-Provisioned VPNs)
- the layering concepts set out in ITU-T G.805 (a generalized multi-technology layered model)

The layered concepts of ITU-T G.805 have been extended using encapsulations identified from real network element behaviour to provide modelling and performance advantages for information transfer between the management systems. This document provides an explanation of the layering and encapsulation and then builds a view of the use of the layered components in a large number of network scenarios.

The MTNM model also provides support for:

- ASON Control Plane. Much of the detail is covered by a separate pair of supporting documents (SD1-45_ASONControlPlaneManagement-Primer.pdf and SD1-46_ASONControlPlaneManagement-Scenarios.pdf) which should be read in conjunction with this document where ASON Control Plane support is to be implemented/deployed. Support for ASON Control Plane will not be covered by this document.
- Sophisticated Ethernet applications (such as VLAN). Much of the detail is covered by a separate supporting document (SD1-44_ConnectionlessTechnologyManagement.pdf) which should be read in conjunction with this document where Ethernet support is to be implemented/deployed. Only basic Ethernet support will be covered by this document.

Of most concepts two views are provided:

- For readers familiar with the concepts of ITU-T G.805 there is an extensive set of figures mapping the MTNM model to G.805 layering. The key to Figure 2 (on page 12) and Figure 3 (on page 14), supplemented by Figure 4 (on page 15) for inverse multiplexing and further MTNM symbols for directionality and monitoring, provides a key to MTNM symbols used throughout the document.
- For readers familiar with standard network element operations, but not so familiar with ITU-T G.805, there is an extensive set of network element oriented figures and descriptions. See Figure 10 (on page 19), Figure 13 (on page 23), and Figure 14 (on page 26) for details.

Throughout this document abbreviated forms of transmission layer rates are used whose long forms are defined in the supporting document SD1-17_LayerRates.pdf. For example, LR_STS3c_and_AU4_VC4 is normally abbreviated to VC4 in the descriptive sections relating to SDH, and to STS3c in sections relating to SONET.

The document is divided into a number of major sections and it is recommended that these sections be read in order as each builds on the previous. Once this document has been studied the reader should be able to construct models of the network devices to be managed and understand how interconnection of these Managed Elements in the network should be modelled. The sections are summarised below:

- Section 3 MTNM Model in terms of Layering and Equipment on page 11 provides details the MTNM traffic model in terms of termination points their layering encapsulation and interconnect ability. The section explains the modelling of PTPs, CTPs and FTPs and then uses these components to explain the modelling of concepts such as non-intrusive monitoring, inverse multiplexing, remote unit encapsulation. There are also explanations of where to break a flow of TPs to form CTPs, where TPs should be encapsulated in FTP and where fixed crossconnects/SNCs should be used. The section should provide all necessary information and rules to allow the construction of a model of a Managed Element in any of the supported technologies. In other words, this section provides the rules for TP modelling.

- Section 4 Specific Cases of TP Layering on page 49 provides examples of models for particular types of ports. The examples in this section are certainly not exhaustive, but should be used as templates for ports within the equipment to be modelled. The introduction of the section provides a summary of the models provided and some cross references to the models in subsections.
- Section 5 Fixed Crossconnect Usage on page 94 provides a brief summary of the use of fixed crossconnects in the context of Termination points by way of some basic examples.
- Section 6 Topological Links on page 96 provides an overview of topological links and sets out rules for their usage by means of example In the context of termination points within Managed Elements.
- Section 7 Subnetwork Layering and Topological Links 103 provides an overview of topological links in the context of subnetworks.
- Section 8 SNC versus TL, Trail and Network Connection Modelling on page 106 provides strict rules for combinations of Topological Links and SNCs. It provides an explanation of SNCs and Topological Links in terms of Trails and Network Connections (both of which may be more familiar terms to those who are conversant in ITU-T modelling). The section highlights by example where SNCs and Topological links may be combined and where not in terms of layered TPs.

There are a number of related supporting documents that provide further details on aspects of the model and of network technologies that may also assist the reader of this document. These are:

- SD1-3_BundledSNC.pdf – The interface supports simultaneous operations on SNCs grouped in Bundles. This document explains the concept and usage of Bundled SNCs.
- SD1-6_ContainedTPs.pdf – provides specific naming details for a number of cases of TP containment using the layered model and is a companion to SD1-25_objectNaming.pdf
- SD1-7_DSLOverview.pdf – provides an overview of DSL technology
- SD1-10_EquipmentModel.pdf – Specifies the equipment model and equipment states
- SD1-14_IMOverview.pdf – Provides an overview of Inverse Multiplexing
- SD1-16_LayeredParameters.pdf – The interface is built around a layered model this document provides a specification of and explanation of the parameters may be reported and configured in the context of the layered TP model
- SD1-17_LayerRates.pdf – Provides a list of supported transport layer along with their naming and a method for adding new layer where currently not supported.
- SD1-19_LocationIdentification.pdf – Defines the usage of “Contra Directional” in the context of PM location
- SD1-23_ModesOfOperation.pdf – There are several ways that an NMS may choose to use the SNCs, this document explains these various modes of operation.
- SD1-25_objectNaming.pdf – Provides an overview and specification of the object naming used across the interface
- SD1-29_PGPParameters.pdf – Provides a specification and explanation of the Protection Group Parameters
- SD1-34_protectionSwitch.pdf – Provides an overview of the protection switching model and operations for Trail protection applied to a number of example scenarios
- SD1-35_SNCStateDiagram.pdf – Provides an explanation and specification of the various states of the SNC

- SD1-36_SNCTypes.pdf – The SNC is a fundamental component in the provision of connectivity across the network. This document defines the SNC types and provides examples of their usage
- SD1-41_TPPoolRelationship.pdf – Explains the relationship between TP Pools and the TP.
- SD1-42_trafficParameters.pdf – Provides a specification of and explanation of traffic parameters

As stated above there are supporting documents that cover that cover Ethernet VLANs and ASON Control Plane model and application. It should be noted that many of the supporting documents above provide information related to Ethernet VLAN support and ASON Control Plane support and should therefore be read in conjunction with the following documents:

- SD1-44_ConnectionlessTechnologyManagement.pdf – Provides an overview of the support for connectionless technologies focussing on Ethernet.
- SD1-45_ASONControlPlaneManagement-Primer.pdf – Provides an overview of the ASON Control Plane support provided by the interface and how the interface might be used.
- SD1-46_ASONControlPlaneManagement-Scenarios.pdf – Provides an explanation of a number of applications of the ASON Control Plane and shows how these relate to the model.

Referenced have been added as appropriate through out this document to aid navigation to the appropriate explanatory material.

If you have questions or comments related to this document please refer to section *How to comment on the document*.

3 MTNM MODEL IN TERMS OF LAYERING AND EQUIPMENT

The following sections introduce the reader to the MTNM model in terms of layering and real equipment.

This chapter introduces the concepts behind the MTNM modelling components for termination point (TP)s:

- Physical Termination Point (PTP)
- Connection Termination Point (CTP)
- Floating Termination Point (FTP)

Some parts of the TP model are subject to interpretation. In these cases, the solution vendors are free to model the TPs as they consider appropriate. However, it is advised

- that where a model is represented in the examples, it is used on the interface
- that where there is an obvious and simple extrapolation required to achieve a model of an NE this extrapolation is followed
- that in all cases regardless of the apparent deviation of the NE to be modelled all possible attempts are made to follow the essence of the examples and the rules set out below

For explanation of the Ethernet CPTP model and the ASON Control Plane “point” model see SD1-44_ConnectionlessTechnologyManagement.pdf, SD1-45_ASONControlPlaneManagement-Primer.pdf and SD1-46_ASONControlPlaneManagement-Scenarios.pdf.

3.1 MTNM in terms of ITU-T G.805 Layering

The MTNM model aligns with the modelling work carried out in ITU-T described in ITU-T G.805. Refer also to Annex Introduction to G.805 for an overview of G.805 and G.852.2 diagrammatic conventions.

3.1.1 Basic Modelling Concepts

Figure 1 (on page 12) shows an extraction of components from ITU-T G.805. Not all symbols from G.805 are shown and a simplified set of these symbols, described later in this section, are used throughout this text.

Figure 2 (on page 12) shows the MTNM interface objects overlaid with stylized G.805 objects. The diagram represents two ports (PTPs) of a network element. The port to the left could be a DS3 trib of an OC3 mux and the port to the right could be an OC3 port on the same mux that is capable of both connecting STS1 unterminated and also of terminating to produce VT1.5 payload. The figure does not show the number of STS1 CTPs available (potentially 3) nor the number of VT1.5 CTPs available (potentially 84) but does show an STS1 SNC connecting an STS1 CTP to a DS3 port. Clearly this STS1 CTP is not available for termination to VT1.5. The interaction of SNCs and TerminationMode is covered in section 3.6.2 (on page 24). This is also shown in Figure 10 (on page 19).

As it can be seen the G.805 model and the MTNM model are very closely aligned around the principles of layering, termination, adaptation[1], and connectivity. It can also be seen that the MTNM model provides in addition a number of encapsulations enabled by the restrictions observed in standard NEs; an example of such a restriction is that many of the layers associated with a port are quite static and not of interest and therefore do not need to be modelled in full detail.

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[1] Adaptation capabilities of a particular PTP may be restricted such that usage of CTPs in one layer impacts the availability of CTPs in another layer (e.g., the interaction between VC12 and VC3 within a single VC4). The MTNM model presents an "optimistic" super set of capabilities for each PTP and uses a resource utilisation model to identify the CTPs that are available at any particular time. Additional capabilities to express such limitations are under study.

These encapsulations have been created to allow a less cluttered model and to reduce the number of exchanges required between the NML and EML over the interface when enrolling NEs and their ports.

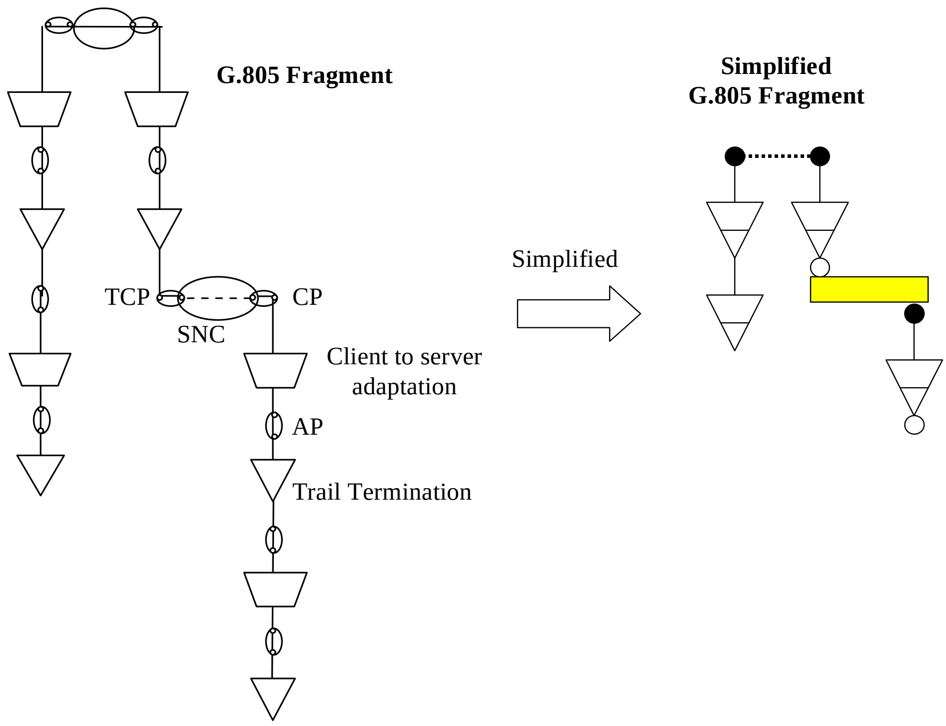


Figure 1 Extract of ITU-T G.805 Layered Model and MTNM Simplification

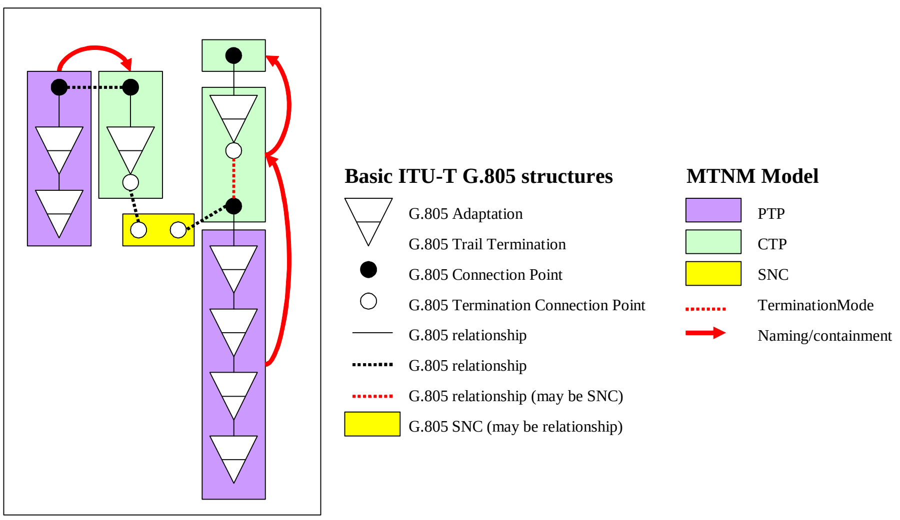


Figure 2 MTNM and G.805 Layered Model

However, the encapsulated layers cannot be totally forgotten as they do play a role in termination and do provide measures and monitors etc. The layers that are encapsulated in a TP (i.e., PTP or CTP or FTP) are exposed in MTNM via the **Layered Transmission Parameters** of the TP; refer to the supporting document SD1-16_LayeredParameters.pdf for a list of transmission parameters per layer supported by this version of MTNM.

It should be noted that the term G.805 TTP has been used throughout the text to refer to the assembly of G.805 Trail Termination (TT) function and associated G.805 Termination Connection Point (TCP) (see also Figure 128 Transport Network Resource Model (G.852.2) on page 130), even if the TCP is not shown in every case. In addition the term G.805 CP has been used to refer to the G.805 Connection Point.

The assembly of G.805 TT function and associated G.805 TCP, i.e. the G.805 TTP, is always encapsulated in the same MTNM TP.

The layer of an MTNM TP is called “terminated” if the TP encapsulates a TTP at this layer and either no CP at this layer or a CP at this layer that is attached to the TCP of the TTP (and is not potentially or actually crossconnected). The attachment capability is depicted by a red dotted line in the figures that may be drawn undotted when the attachment is actually made or is inflexible.

3.1.2 Floating Termination Point

In the MTNM version 3 interface the FTP is introduced. Figure 3 (on page 14) shows the MTNM interface objects including the FTP overlaid with stylized G.805 objects (similar to Figure 2 on page 12). The diagram shows two ports (PTPs) of a network element with an internal “floating” termination, the FTP. The FTP is used where a termination point can not be identified with a physical port by following non-adjustable traffic flow (this is in effect the rule for a PTP) and can not be associated with a single PTP (but only with multiple PTPs) following adjustable traffic flow (which is the case for a CTP). It is therefore floating regarding its position within the network element. This will be further explained later in this document.

As an example, the port to the left in Figure 3 could be a DS1 trib of a SONET mux and the port to the right could be an OC3 port on the same mux. Then the OC3 port is capable of connecting STS1 unterminated to internal STS1 terminations (the FTP) that themselves map to VT1.5. These STS1 terminations may potentially be protected at the STS1 layer (i.e., may connect to two different OC3 ports), but Figure 3 shows an unprotected case. The VT1.5 channels of the STS1 termination in the FTP connect to the DS1 tribs which may be protected at the VT1.5 layer (i.e., may connect to the CTPs of two different FTPs).

The figure does not show the number of STS1 CTPs available (potentially 3) nor the number of VT1.5 CTPs available (potentially 84) but does show an STS1 SNC connecting an STS1 CTP to an FTP which produces VT1.5 payload and has one of its VT1.5 CTPs connected to a DS1 port. The interaction of SNCs and TerminationMode is covered in section 3.6.2 (on page 24) and section 3.7.2 (on page 29).

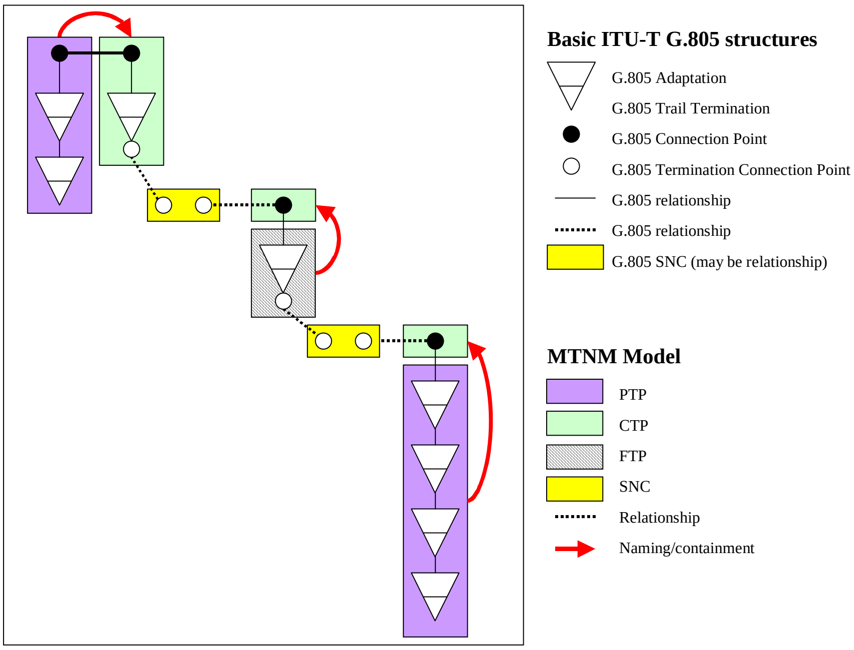


Figure 3 MTNM and G.805 Layered Model

3.1.3 Inverse Multiplexing (IM) Principles

The extended G.805 model shown in Figure 4 on page 15 depicts a multiplexing situation where the client bit rate is higher than that of the server. There are various protocol mappings specified that support high rate clients carried by multiple lower rate servers. In these cases the server layer signals each carry a fragment of the client signal in parallel across the network and these fragments are concatenated at the receive end to reassemble the client signal. This process is classified as inverse multiplexing (IM).

G.805 uses the adaptation symbol to show the fragmentation part of inverse multiplexing and the same symbol has been adopted by MTNM for simplicity of interpretation.[2] A repeated black square symbol represents the point where the relationship of the fragmentation to the server fragments is made.

[2] In version 2.1 CTP type I (identified as not supported) used an inverted symbol. This has now been corrected to line up with ITU-T.

These symbols are further developed in the TP models in the following sections (including a description of forms of CTPs and FTPs that support inverse multiplexing in section 3.6 CTP Layering on page 21 and section 3.7 FTP Layering on page 27).

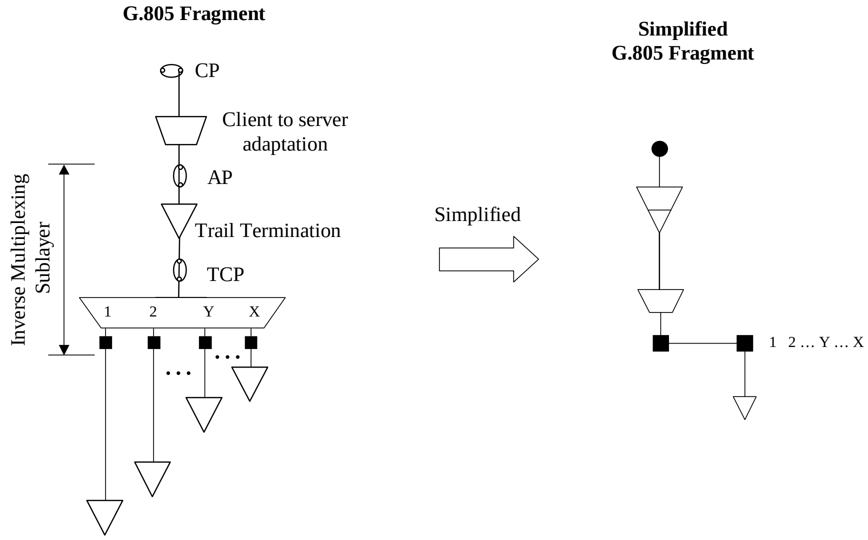


Figure 4 Extract of ITU-T G.805 Layered Model for IM and MTNM Simplification

Refer to section 3.11.5 on page 46 for guidelines for the construction of IM models.

3.2 Optical Layer Encapsulation

ITU-T G.707 and G.709 identify a number of layers in the SDH/SONET and OTN/WDM problem spaces. ITU-T G.805 identifies the concept of sublayers that are themselves encapsulated (and thus hidden) within the termination points of other layers. An example from SDH/SONET of a sublayer is the Multiplex Section Protection (MSP) layer (identified in ITU-T G.803) which is hidden within the Multiplex Section (MS) layer.

The layers used in the MTNM definition (identified by the LayerRate parameter) in some cases do encapsulate sublayers. For example the Tandem Path Monitoring capabilities of some VC4 CTPs could be considered as really aspects of the VC4 Tandem Path (sub)layer. In this case, the encapsulated layer capabilities would be represented via Layered Transmission Parameters.

This layer encapsulation also occurs in the optical layers. In ITU-T G.709 a number of layers have been defined to deal with capabilities such as Tandem Connection Monitoring (TCM) and Forward Error Correction. Prior to release 3 of the MTNM interface these layers were doubly encapsulated as follows:

- OTU, ODU, OPU layers form ITU-T G.709 are encapsulate in the digital signal rate (DSR) layer of the MTNM model. Note that in addition, if the framing format is known for the digital signal rate, the corresponding rate is suffixed to the DSR.
- OCC and OCH of ITU-T G.709 are encapsulated in the OCH layer of the MTNM model.

This simple encapsulation is still available in release 3 and is shown in Figure 5 on page 16. In this model the OMS and OTS layers are unaffected and do not currently encapsulate any sublayers.

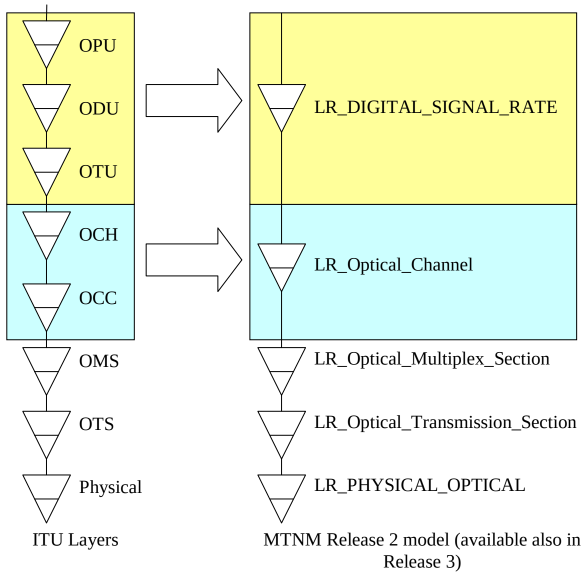


Figure 5 Layer Encapsulation in the Optical Layers

In the release 3 definition of the MTNM interface it is also possible to provide a full representation of these layers in the definition of a TP so that both the double encapsulated approach and the explicit approach are available. The new layers LR_OCH_Data_Unit_1, LR_OCH_Data_Unit_2 and LR_OCH_Data_Unit_3 along with LR_OCH_Transport_Unit_1, LR_OCH_Transport_Unit_2 and LR_OCH_Transport_Unit_3 may be used (see also Figure 6 ITU-T G.709 OTN layers on page 16).

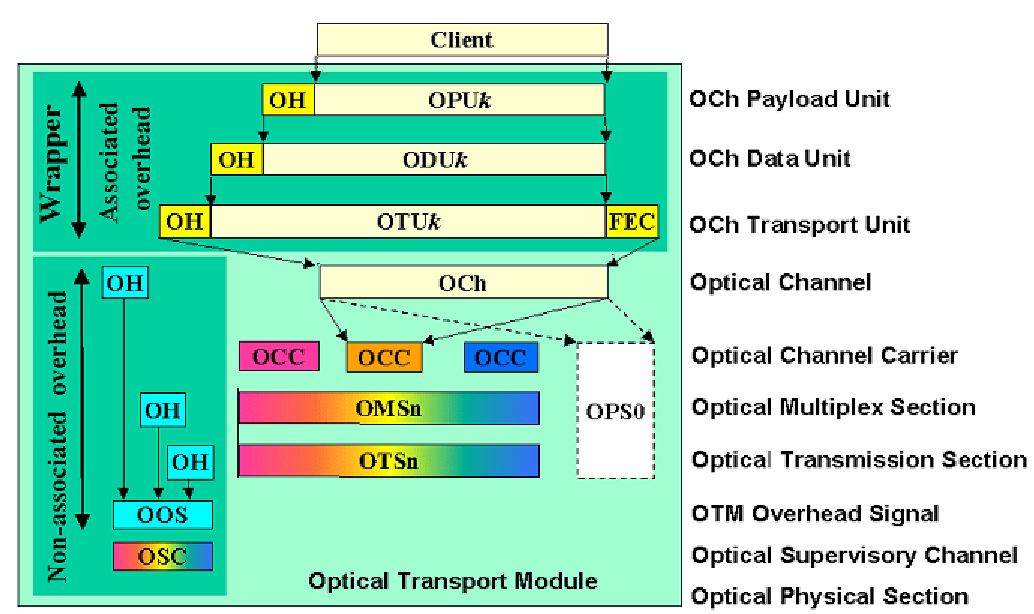


Figure 6 ITU-T G.709 OTN layers

Examples have been added to this version of the document to show the full model of a WDM optical port (see 4.2.12 OTS port supporting G.709 DSR, ODU and OTU on page 61 and following sections for example templates).

The OMS and OTS layers are again unaffected and do not currently encapsulate any sublayers. The enhanced model is shown in Figure 7 Enhanced encapsulation for the Optical Layers showing OTU 2 on page 17 and Figure 8 Enhanced encapsulation for the Optical Layers showing OTU 1 on page 17.

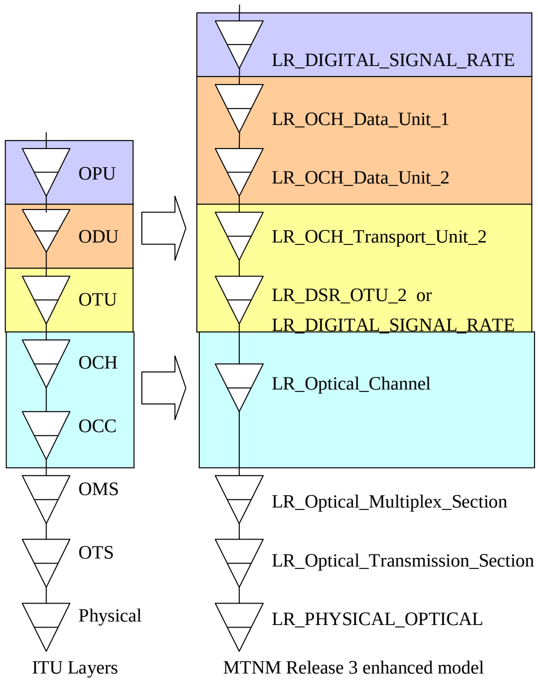


Figure 7 Enhanced encapsulation for the Optical Layers showing OTU 2

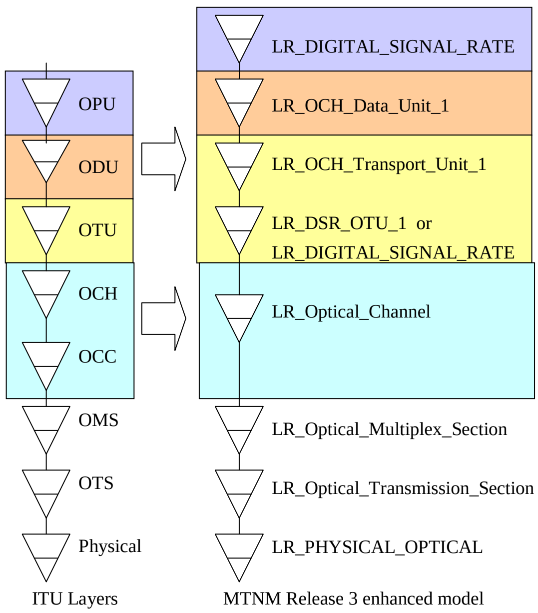


Figure 8 Enhanced encapsulation for the Optical Layers showing OTU 1

3.3 TP Layering

An MTNM TP encapsulates one or more G.805 transmission layers and presents them to the NML.

3.3.1 Providing TP Layering Information

To allow the client application to interpret inter-port compatibility (inter-PTP/FTP as well as inter-CTP), a TP must present a list of layers that it comprises. For example, an OC3 PTP comprises several layers including SONET Line, SONET Section, and Optical.

A TP includes the attribute transmissionParameters which is structured as LayeredParameterList which is a sequence of LayeredParameters (see SD1-16_LayeredParameters.pdf for the standard parameters) structures that include LayerRate (see SD1-17_LayerRates.pdf) and a list of layer-specific transmissionParameters (NVSList). The expected layer lists for a variety of TPs is covered in chapter 4 (on page 49).

The layers of a TP are identified in the Layered Transmission Parameter structure. If a layer is identified for a TP, the layer must be indicated in this structure even if there are no specific parameters to convey. The layers should be conveyed in order starting at the lowest server layer. In the examples in chapter 4 Specific Cases of TP Layering (on page 49) the layer list is effectively given by the layers stated in the figures reading from bottom to top in each case.

Prior to release 3, although the list of layers were in order of position in the multiplexing hierarchy, there was no intended list order meaning in the interface and the EML could report the layers of a TP in any order. From release 3 onwards, the layers of a TP are listed starting with the server-most or lowermost layer; each layer is then followed by its client layer(s). The server-most layer of a PTP is always its physical layer.

3.3.2 Layering Options

Some PTPs may have several alternative layering presentations, either due to specific configurability or due to the need to represent alternative model compatibility. When there are alternative layer choices the transmissionParameter THIS_LAYER_ACTIVE is used. The parameter is provided with each of the optional/alternative layers and set to INACTIVE when the layer is not involved in the termination of signals and ACTIVE when it is involved in the termination of the signal. See Figure 9 on page 18. This concept is best covered via example (see section 4.4.3 on page 76).

In the case where there are several optional layers the layers should be listed in the appropriate order such that all legal active combinations are represented in the order of signal flow as defined in section 3.3.1 Providing TP Layering Information on page 18. The adaptation function of a layer below an inactive layer is in effect assumed to have adjusted to be compatible with the first active layer above.

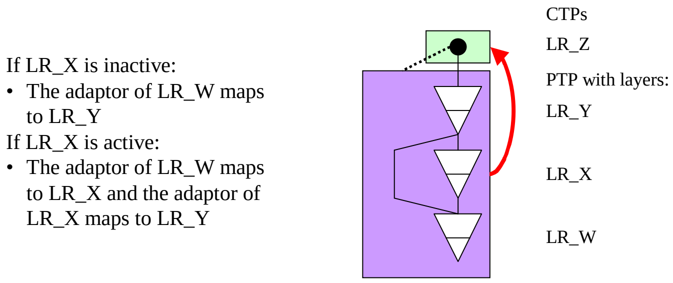


Figure 9 Optional Layers behaviour

In some cases end-to-end compatibility is achievable although one end is supporting an optional layer and the layer is active and the other end does not support the layer or the layer is inactive. This is true for Tandem Connection Monitoring optional layers (see section 3.9.2 on page 35).

3.3.3 Layer in CTP name

Where the TP name includes a layer component, always the case for a CTP, this should be the name string of the lowest server layer (this is marked in many of the examples). This is the connectable layer if the CTP has a connectable layer. If the CTP is capable of inverse multiplexing adaptation the encapsulated fragment layer is lowermost but is not considered for naming. The name strings can be found in the supporting document SD1-17_LayerRates.pdf. TP naming is covered in the supporting document SD1-25_objectNaming.pdf. See also section 3.12 CTP Naming Summary on page 48.

3.4 MTNM in terms of Network Element Equipment

The diagram in Figure 10 (on page 19) shows an SONET OC3 NE with DS3 Tribs. The OC3 ports are supported by Line cards and provide mapping to STS1 (for possible interconnection to DS3 Tribs) and to VT1.5 for interconnection between the line ports. In this particular NE example there are no DS1 ports for interconnectivity. In this case an SNC is shown connecting an STS1 CTP of a DS3 port to an STS1 CTP of the OC3 port (thus making the VT1.5 CTPs of that STS1 unavailable) and a second SNC is shown connecting a VT1.5 of STS1#3 of the left line port to a VT1.5 of STS1#2 of the right line port. The STS1#3 CTP on the left line port and the STS1#2 CTP on the right line port have both tpTerminationMode TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING (see 3.6.2 on page 24).

This basic NE is also shown and described in section 3.1.1 (on page 11) in terms of ITU-T G.805.

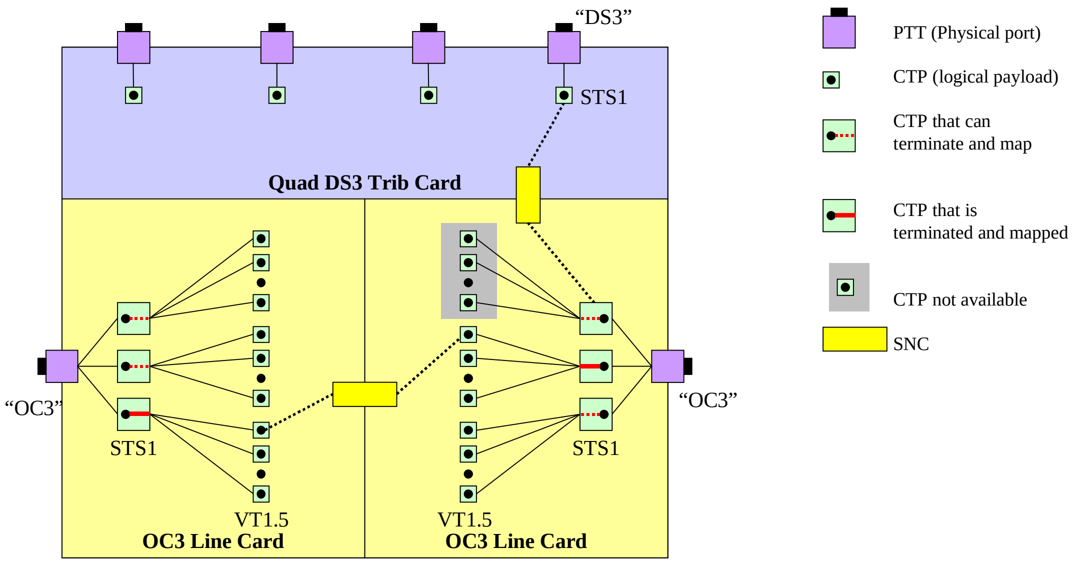


Figure 10 MTNM and a Network Element Model

From an equipment perspective, the key to the model is the encapsulation of capabilities that represent the physical port (i.e., the PTP), where there is little flexibility and little to describe, and the expansion of the model into separate CTPs, where there is significant flexibility and much more to describe.

3.5 PTP Layering

This section describes the types of PTPs and their layer encapsulation structures that can and should be used in the MTNM model..

3.5.1 Overview

A PTP is used on any occasion where a physical port is to be represented. As can be seen from the diagram in Figure 11 (on page 20) (giving both G.805 layering and equipment representations) there are two distinct flavours of PTP.

A PTP may for example represent the:

- SONET port (an OC3 physical port in Figure 11 on page 20) of an NE where the CTPs contained are associated by adaptation and represent solely client layers of the encapsulated G.805 TTPs of the PTP

  This type of PTP is shown below as **PTP A**.

  This type of PTP encapsulates only terminated layers.

  This type of PTP contains CTPs that further demultiplex the signal that flowed in through the physical port ("same orientation client containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

- Async port (a DS3 physical port in Figure 11 on page 20) of the NE where the CTPs contained are associated by connection rather than simply adaptation and represent a peer layer carrying the connected client signal

  This type of PTP is shown below as **PTP B**.

  This type of PTP encapsulates the G.805 CP of the uppermost client layer (black dot in the diagram), which is not terminated.

  This type of PTP contains CTPs that multiplex the signal that flowed in through the physical port and that was demultiplexed by the PTP ("reverse orientation client containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

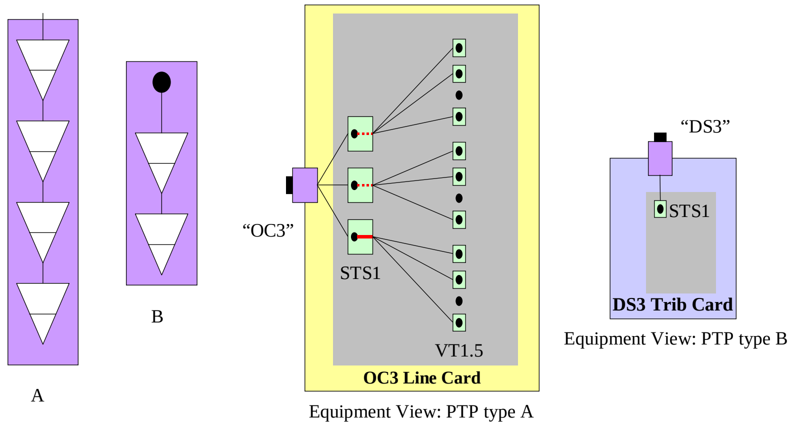


Figure 11 PTP variety and layering

This principle applies in general so the same is true of DWDM NEs and ATM NEs. So for example the circuit emulation capable port of an ATM NE would be represented using PTP B above (see section 4.3.3 DS3 trib circuit emulation port of an ATM NE on page 73).

3.5.2 The use of TerminationMode

A PTP always contains CTPs as clients. Therefore the tpTerminationMode attribute has no meaning for PTPs and consequently TM_NA is the only legal value for a PTP. (See section 3.6.2 The use of TerminationMode on page 24 in case of CTPs and section 3.7.2 The use of TerminationMode on page 29 in case of FTPs for more details of tpTerminationMode.)

3.6 CTP Layering

This section describes the types of CTPs and their layer encapsulation structures that can and should be used in this version of the MTNM model.

3.6.1 Overview

The CTP model is the same as the PTP model in that a CTP is potentially an encapsulation of termination points at multiple layers. However, unlike a PTP, the CTP occurs in an area of the NE where there is high flexibility and as a consequence there are less examples of CTPs that encapsulate multiple layers.

As can be seen from Figure 12 (on page 23) there are several distinct flavours of CTP, two of which, called CTP C and CTP F below, were shown in Figure 2 (on page 12) and also in Figure 10 (on page 19). This is also shown from an equipment perspective in Figure 13 (on page 23). A CTP is always contained in another TP, a CTP, PTP or FTP, the type of CTP contained depends upon the actual application.

There are generic CTP types, that depend on the CTP’s TerminationMode (see section 3.6.2 The use of TerminationMode on page 24), and encapsulation CTP types, that depend on the CTP’s internal structure regarding G.805 layering and encapsulated reference points.

The generic types are “potential”, “in use”/”actual”, and “current”. A contained CTP is called **“potential”** if the containing TP is potentially capable of supporting it in some mapping configuration. A contained CTP is called **“in use”** or **“actual”** if it either is used by an SNC in any state (including “pending”), either as a connection matrix end point or as an intermediate connection point (see chapter 8 SNC versus TL, Trail and Network Connection Modelling on page 106), or is terminated and mapped (with optionally assigned bandwidth) and thus capable of supporting lower rate (i.e., higher layer) connections (such a CTP is often also called “channelized”). An actual CTP is potentially available for connectivity using an SNC and may indeed already be connected by an SNC. A contained CTP is called **“current”** if it is either crossconnectable or crossconnected in the current mapping configuration.

A CTP may for example represent the:

- VC4 component mapped from an STM-4 PTP (where there would be 4 instances of CTP) that is capable of terminating to provide VC12 capacity and also capable of crossconnecting to another CTP associated with another PTP within the NE

  This type of CTP is shown below as **CTP C** (upper type C diagram in the figure). If the CTP is such that there is no flexibility and it must always be terminated, then a short form of diagram may be used as shown (lower type C diagram in the figure).

  In the example this CTP represents the AU4 connection point and VC4 TTP (note that VC4 and AU4 are represented with the same layer rate in the model – see supporting document SD1-17_LayerRates.pdf). The containment relationship to the PTP aligns with the traffic flow from the Adaptor of the Multiplex section TTP to the AU4 connection point.

  This type of CTP would be contained in PTP/FTP/CTP and further demultiplex the signal that flowed in at the base of the containing TP (“same orientation client containment” – see section 3.11.4.2 Layering and Reverse Layers on page 46).

  The STS1 CTP shown attached to the OC3 PTP in Figure 10 on page 19 is also type C.

- STS3c component mapped from an OC12 PTP (where there would be 4 instances of CTP) that is solely capable of crossconnecting to another CTP associated with another PTP within the NE

  This type of CTP is shown below as **CTP D**.

  In the example this CTP represents the AU4 connection point. The containment relationship to the PTP aligns with the traffic flow from the Adaptor of the Multiplex section TTP to the AU4 connection point.

  This type of CTP would be contained in PTP/FTP/CTP and further demultiplex the signal that flowed in at the base of the containing TP ("same orientation client containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

  The VT1.5 CTP shown attached to the STS1 CTP attached to the OC3 PTP in Figure 10 on page 19 is also type D.

- two-layer STS1 component mapped from an OC3 PTP (where there would be 3 instance of CTP) that is capable of crossconnecting to another CTP associated with another PTP within the NE and also capable of terminating to provide DS3 capacity that is itself mandatorily terminated to always provide DS1 capacity

  This type of CTP is shown below as **CTP E**.

  In the example this CTP represents the AU3 connection point, the VC3 TTP, the DS3 connection point and the DS3 TTP (this is often classified as transmux). The containment relationship to the PTP aligns with the traffic flow from the Adaptor of the Multiplex section TTP to the AU3 connection point.

  This type of CTP would be contained in PTP/FTP/CTP and further demultiplex the signal that flowed in at the base of the containing TP ("same orientation client containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

  This type of CTP is not represented in Figure 10 on page 19.

- VC3 component that terminates a signal crossconnected within the NE and adapts it to E3 for output through an Asyn port

  This type of CTP is shown below as **CTP F**.

  In the example this CTP represents the VC3 TTP and the E3 connection point. The containment relationship to the PTP aligns with the traffic flow from the Adaptor of the Electrical Termination of the Async port (which produced the E3 unterminated signal) and the Adaptor of the VC3 TTP that absorbs the E3 signal.

  This type of CTP encapsulates the G.805 CP of the uppermost client layer (black dot in the diagram).

  This type of CTP would be contained in PTP/FTP/CTP and would multiplex the signal that flowed in at the base of the containing TP and that was demultiplexed by the containing TP ("reverse orientation client containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

  The STS1 CTP shown attached to the DS3 PTP in Figure 10 on page 19 is also type F.

- VC4 component that terminates a signal crossconnected within the NE and adapts it to fragments. The fragments will be subsequently assembled by an encapsulation layer termination (for example ATM NI layer) which together with N fragment CTPs form an inverse mux (see section 3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA on page 46).

  This type of CTP is shown below as **CTP K** where the black square represents the point where the relationship to the fragment assembly FTP/CTP is made (upper type K diagram). If the CTP is such that no adaptation is needed, then a short form of diagram may be used as shown (lower type K diagram).

  This type of CTP would be contained in the assembly FTP/CTP and would multiplex the signal that flowed in at the base of the FTP/CTP and that was demultiplexed by the containing TP ("same orientation server containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

- fragment assembly component that takes N fragments (provided by instances of CTP K) and assembles the signal into a single concatenated signal (such as the encapsulation layer) as part of the process of inverse multiplexing (see section 3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA on page 46).

  This type of CTP is shown below as **CTP L**, and also **CTP M** and **CTP N**, where the black square represents the point where the relationship to the fragment CTPs is made.

  CTP M also offers the ability to terminate an SNC (crossconnect) directly on the encapsulation layer (or another client layer of the fragment layer).

  CTP N is a multi-layered version of CTP L but unlike CTP M it offers no SNC capability.

  This type of CTP would be contained in PTP/FTP/CTP and would multiplex the signal that flowed in at the base of the containing TP and that was demultiplexed by the containing TP ("reverse orientation client containment" – see section 3.11.4.2 Layering and Reverse Layers on page 46).

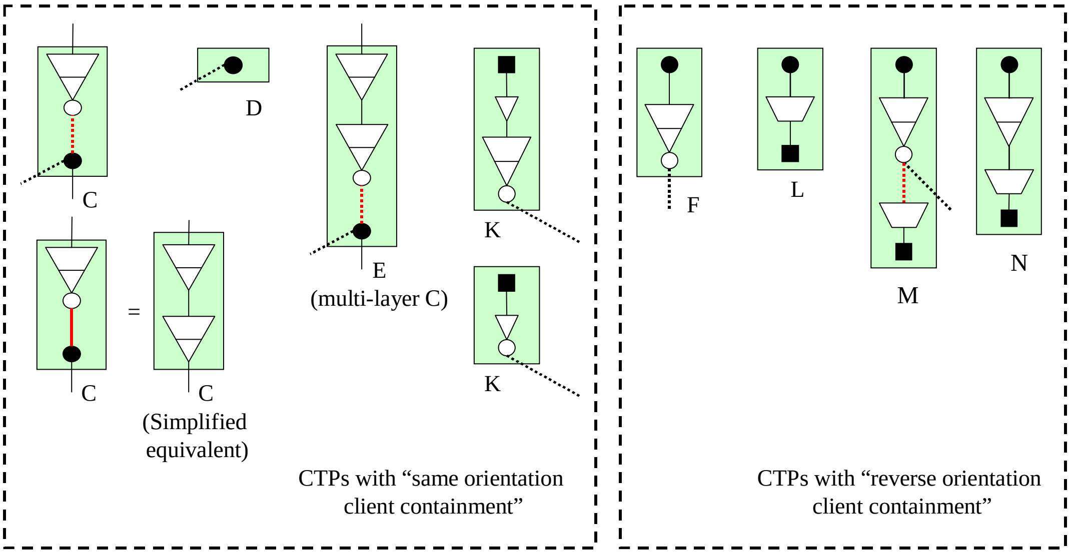


Figure 12 CTP variety and layering

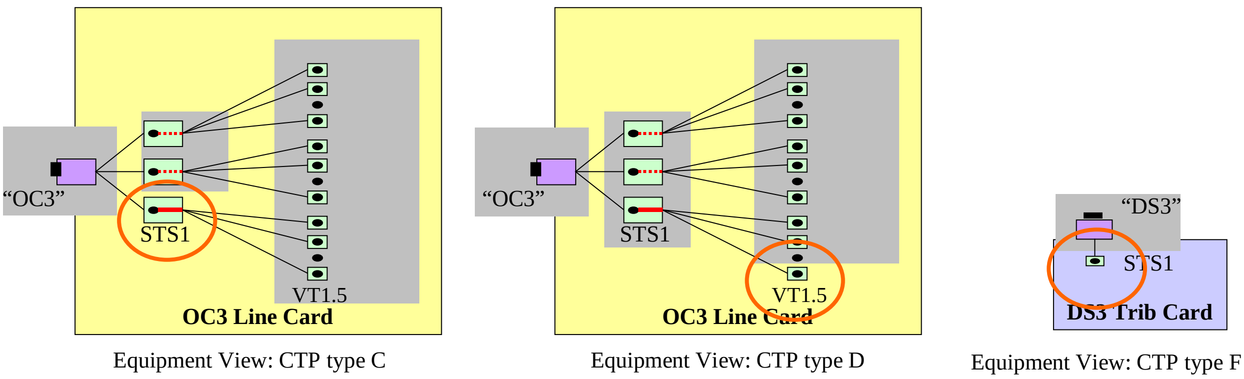


Figure 13 Equipment View: CTP variety and layering

The release 2 interface of MTNM identified a number of CTP structures that were not supported. The concepts embodied by these CTP structures are supported in the release 3 interface using FTPs[3] (see section 3.7.1 on page 27).

3.6.2 The use of TerminationMode

As noted above the CTP offers the potential to convey termination flexibility control and information. The tpTerminationMode attribute of the termination point provides this control. The attribute may control client side contained CTPs or server side CTPs depending upon the type of the CTP.

The three potential values are:

- **TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING** (TM_TAAFM) is a valid state for CTPs that support client side adaptation and for CTPs that support server side adaptation. The state indicates that

  - for the case of a CTP that is contained in another TP of the same orientation ("same orientation client containment"), and where the CTP can be mapped and currently is (i.e., itself has contained actual CTPs):

    From a G.805 perspective, the client G.805 CP is adapted from the corresponding G.805 TTP within the CTP aggregate and is available to provide client layer capacity (e.g., STS1 terminated and mapped to VT1.5 (i.e., channelized)). In this state the TCP will be sourcing and/or sinking traffic.

    When in this state the client CTPs of the CTP may be used for creation of SNCs (crossconnects).

    Both CTP C and CTP E may take this value.

    This is not a valid state for CTP D as it contains no client CTPs.

    When set to this value the traffic will flow via the red dotted line shown in Figure 12 (on page 23) and the SNC (or crossconnect) that would be made via the black dotted line in the figure can not be created.

    From a hardware perspective, a payload has been terminated (for example the STS1 on an OC3 Line port) and has been decomposed to VT1.5 payload ready for connectivity (see Figure 10 on page 19).

  - for the "same orientation server containment" cases the CTP can be mapped and currently is (i.e., itself has contained actual CTPs on the server side):

    This is the case for a CTP that is the client of inverse multiplexed server layers (and thus contains the server CTPs).

    This value is the only value that applies to CTP L and CTP N as there is no alternative other than to offer contained server CTPs (see also section 3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA on page 46).

    When in this state the server CTPs of the CTP may be used for creation of SNCs (crossconnects).

    When CTP M is set to this value the traffic will flow via the red dotted line shown in Figure 12 (on page 23) and the SNC (or crossconnect) that would be made via the black dotted line in the figure can not be created.

- **TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING** (TM_NTNAFM) is a valid state for CTPs that support client side adaptation and for CTPs that support server side

[3] For ease of traceability the FTP type names match the CTPs that were described in release 2.

adaptation.
The state indicates that

- for the case of a CTP that is contained in another TP of the same orientation ("same orientation client containment"), and where the CTP can be mapped but currently is not (i.e., it does have contained potential CTPs but currently has no contained actual CTPs):

  From a G.805 perspective, the G.805 CP is not adapted from the corresponding G.805 TTP within the CTP aggregate and is not available to provide client layer capacity. In this state the TCP will not be sourcing and/or sinking traffic (see also section 3.9 Monitoring on page 31).

  When in this state the CTP is potentially available for connectivity using an SNC (and may indeed already be connected by an SNC).
  NOTE: It is the G.805 CP and not the G.805 TCP that can be used for connectivity.

  When in this state the client CTPs of the CTP are not available for creation of SNCs (crossconnects).

  Both CTP C and CTP E may take this value.

  This is not a valid state for CTP D as it contains no client CTPs.
  NOTE: This is a change to the behaviour from that of version 2 of the interface. In version 2 CTP D always took the value TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING. In version 3 CTP D always takes the value TM_NA.

  When set to this value the traffic does not flow via the red dotted line shown in Figure 12 (on page 23) and the SNC (or crossconnect) that would be made via the black dotted line in the figure can be created.[4]

  For example an STS1 in this state is not terminated and not mapped to VT1.5 (i.e., not channelized).

  For example from a hardware perspective, an STS1 CTP of an OC3 PTP that has been connected to the STS1 CTP of a DS3 PTP in this state (see Figure 10 on page 19).

- for the "same orientation server containment" cases where the CTP can be mapped but currently is not (i.e., the contained CTPs on the server side are not available and can not be connected via an SNC (= crossconnect)):

  This is the case for a CTP that is the client of inverse multiplexed server layers (and thus contains the server CTPs) but may be configured to not use the server CTPs. This type of CTPs is shown in Figure 12 (on page 23) as CTP M.

  When CTP M is set to this value no traffic will flow via the red dotted line shown in Figure 12 (on page 23) and it is possible to create an SNC (or crossconnect) to the TCP of the CTP (via the black dotted line in the figure).

  When in this state the server CTPs of the CTP may not be used for creation of SNCs (crossconnects).

- **TM_NA** indicates that

  - for the case of a CTP that is contained in another TP of the same orientation ("same orientation client containment"), and where the CTP can not be mapped (i.e., it has no contained potential CTPs):

[4] This does not prevent the CTP from carrying out supervisory functions including passive monitoring of Trail Trace and performance values (see section 3.9 Monitoring on page 31). Any such capabilities would be controlled via transmission parameters of the CTP and possibly via layer rates that are present for monitoring purposes only.

From a G.805 perspective, the CTP exposes a CP for connectivity to other TPs (e.g., STS1 termination on SONET PTP that does not offer the capability to map to any clients so it does not offer VT1.5s etc, or ATM VC termination on ATM VP in a core ATM network where no adaptations of ATM cells can take place).

This is the only valid state for CTP D as it contains no client CTPs.

NOTE: This is a change to the behaviour from that of version 2 of the interface. In version 2 CTP D always took the value TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING. In version 3 CTP D always takes the value TM_NA.

For example from a hardware perspective, a VT1.5 CTP of an OC3 line card is in this state (see Figure 10 on page 19).

- for the "same orientation server containment" cases where the CTP does not offer server side contained CTPs, and for the "reverse orientation client containment" cases:

From a G.805 perspective, the CTP only exposes a TCP for connectivity to other TPs (e.g., STS1 termination on a DS3 PTP).

This is the only valid state for CTP K as it contains no server CTPs, and likewise for CTP F.

For example from a hardware perspective, an STS1 CTP of a DS3 trib card is in this state (see Figure 10 on page 19).

Specific examples of the usage of TerminationMode are given throughout the following sections. In addition Figure 14 (on page 26) shows two example cases. In the unterminated case (i.e., TM_NTNAFM) the VT1.5 CTPs are not available for connectivity and if one of these VT1.5 CTPs forms part of a requested SNC, the STS1 CTP will be automatically Terminated and Mapped assuming that it is not already involved in an active STS1 SNC (in which case the VT1.5 SNC request will be rejected).

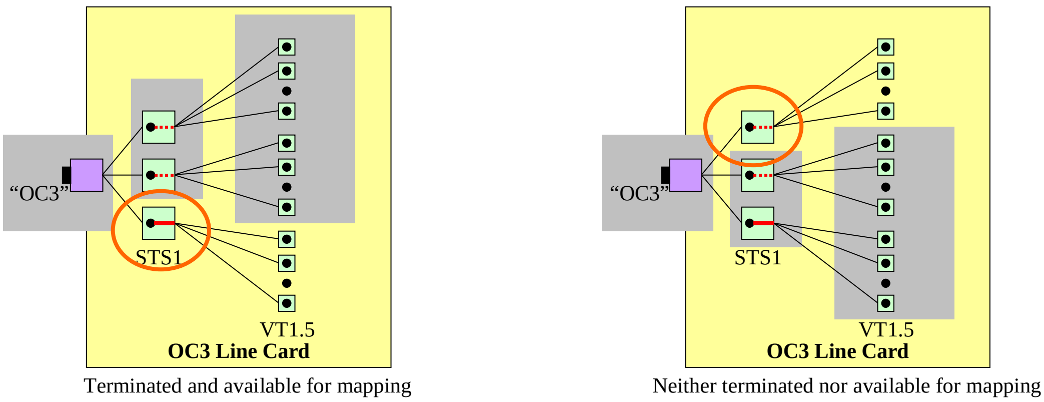


Figure 14 Termination Mode examples

Further very detailed examples for the use of TerminationMode and the generic CTP types can be found in the supporting document SD1-6_ContainedTPs.pdf.

3.6.3 CTP types not covered by the release 3 MTNM interface

Figure 15 on page 27 shows a number of CTP types that are not formally covered by the release 3 MTNM interface. (As previously annotated the CTP types G and I not covered in release 2 are covered by FTP types G and I in release 3.) The behaviour of TerminationMode has not been described.

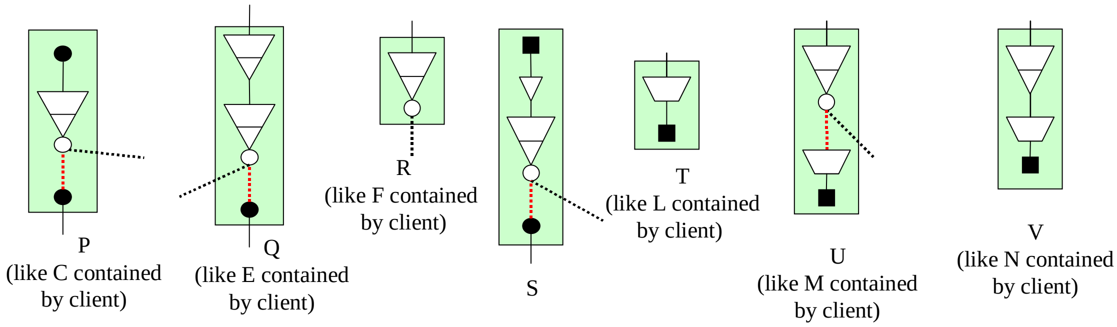


Figure 15 CTP types not covered

These types may be detailed in later releases of the MTNM interface.

3.7 FTP Layering

This section describes the types of FTPs and their layer encapsulation structures that can and should be used in this version of the MTNM model.

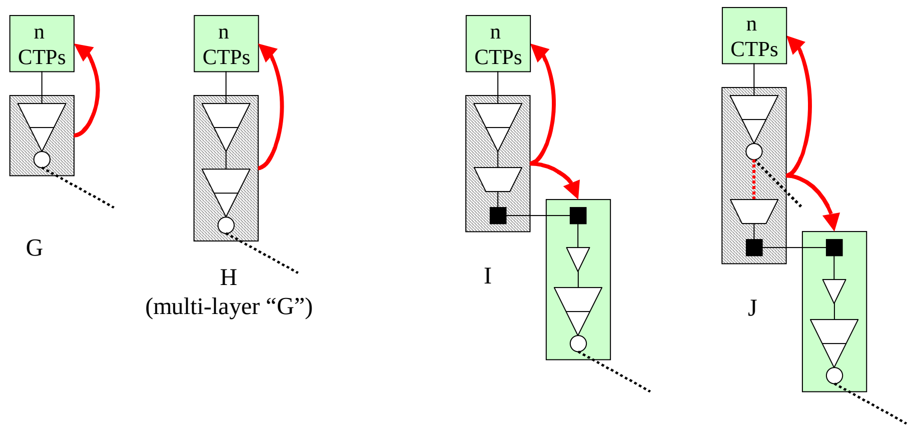
3.7.1 Overview

The FTP model is a hybrid of the PTP model and the CTP model. It is an encapsulation of termination points, potentially at multiple layers. Like a PTP the FTP always contains CTPs on the client side. However, unlike a PTP, but like a CTP, the FTP may contain CTPs on the server side.

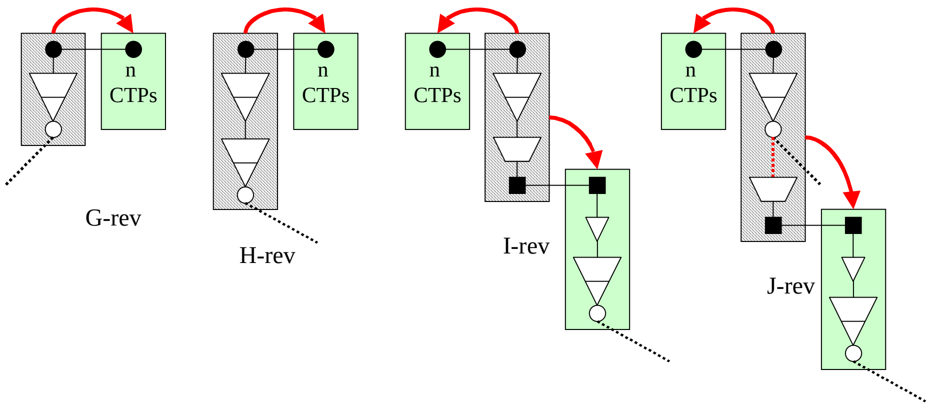
As can be seen from Figure 16 FTP Variety and layering (also showing CTPs) on page 28 there are several distinct flavours of FTP (one of which are shown in Figure 3 MTNM and G.805 Layered Model on page 14). A FTP is never contained in another TP.

Like the PTP there are two distinct orientations on the client side “same orientation client containment” and “reverse orientation client containment” – see section 3.11.4.2 Layering and Reverse Layers on page 46.

The FTP represents an internal resource of the ME, which has no network routing relevance. In other words, the entry/exit points to/from an ME are only the CTPs contained by PTPs. The FTP plays the role of an internal connection point. Typically these FTP instances represent the matrix ports of the ME. To avoid that the NMS has to choose the FTP instance (which would be fairly inconvenient), release 3 of the MTNM interface offers the capability to specify, at SNC creation time, a generic end point (which in the example here is identified by the FTP name "EMS_assigned"). This feature is called EMS assignment of trail end points (see also SD1-25_objectNaming.pdf).



FTPs with "same orientation client containment"



FTPs with "reverse orientation client containment"

Figure 16 FTP Variety and layering (also showing CTPs)

An FTP may for example represent the:

- VC4 component that terminates a signal crossconnected within the NE (from perhaps a VC4 CTP produced by an STM-4 PTP) that may be the closure point of a protection switch and that then adapts to VC12 providing VC12 CTPs available for crossconnection within the NE, again potentially via a protected connection.

  This type of FTP is shown above as **FTP G** where there is only a single layer of termination and FTP H were there are multiple layers of termination

- Fragment assembly component that takes N fragments (provided by instances of CTP K) and assembles the signal into a single concatenated signal (such as the Encapsulation layer) as part of the process of inverse multiplexing (see section 3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA on page 46).

  An example of this is ATM NI that combines a number of independent STS1 streams to form a single composite signal that is then adapted to form ATM VPs. This ATM NI CTP is as shown in FTP I. The FTP has a contained CTP that is and the associated fragment layer CTP. There are also similar examples in SDH/SONET and other technologies.

  This type of FTP is shown below as **FTP I** and also **FTP J** (where the black square represents the point where the relationship to the fragment CTPs is made)

  FTP J also offers the ability to terminate an SNC (crossconnect) directly on the encapsulation layer

  FTP I unlike FTP J it offers no SNC capability

3.7.2 The use of TerminationMode

As noted above the FTP offers the potential to convey termination flexibility control and information. The tpTerminationMode attribute of the termination point provides this control. The attribute always controls to the CTPs contained in the server side of FTPs and these are always "same orientation server containment" cases.

The three potential values are:

- **TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING** (TM_TAAFM) is a valid state for FTPs that support server side adaptation. The state indicates that:
  - the FTP can be mapped and currently is i.e. has contained actual CTPs on the server side.

    This is the case for a FTP that is the client of inverse multiplexed server layers (and thus contains the server CTPs).

    This value is the only value that applies to FTP I as there is no alternative other than to offer contained server CTPs (see also section 3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA on page 46).

    When in this state the server CTPs of the FTP may be used for creation of SNCs (crossconnects).

    When FTP J is set to this value the traffic will flow via the red dotted line shown in Figure 12 (on page 23) and the SNC (or crossconnect) that would be made via the black dotted line in the figure can not be created.

- **TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING** (TM_NTNAFM) is a valid state for FTPs that support server side adaptation. The state indicates that:
  - the FTP can be mapped on the *server* side but currently is not (i.e., it does have contained potential CTPs on the *server* side, but currently has no contained actual CTPs on the *server* side).

    This is the case for an FTP that is the client of inverse multiplexed server layers (and thus contains the server CTPs) but may be configured to not use the server CTPs (i.e. FTP J).

    When FTP J is set to this value no traffic will flow via the red dotted line shown in Figure 12 (on page 23) and it is possible to create an SNC (or crossconnect) to the TCP of the FTP (via the black dotted line in the figure).

    When in this state the server CTPs of the FTP may not be used for creation of SNCs (crossconnects).

- **TM_NA** indicates that:
  - the FTP can not be mapped on the *server* side (i.e., it has no contained potential CTPs on the *server* side).

    From a G.805 perspective, the FTP only exposes a TCP for connectivity to other TPs (e.g. STS1 termination on a DS3 PTP).

    An SNC/crossconnect can be used to connect the G.805 TCP of the FTP to the CP/TCP of another TP.

    This is the only valid state for CTP G and CTP H as they contain no server CTPs.
  - the FTP supports IM (Inverse Multiplexing) indicates that the server side contained CTPs are available for connection as the FTP is actively assembling the fragments of the IM. This value is not valid for an FTP that does not support IM. This applies to FTP I and FTP J.

Specific examples of the usage of Termination Mode are given throughout the following sections. In addition Figure 14 (on page 26) shows two example cases. In the unterminated case (Neither terminated....) the VT1.5 CTPs are not available for connectivity and if one of these VT1.5 CTP forms part of a requested SNC, the STS1 CTP will be automatically Terminated and Mapped assuming that it is not already involved in an active STS1 SNC (in which case the VT1.5 SNC request will be rejected).

3.7.3 FTP types not covered by the release 3 MTNM interface

Not all cases of FTP CTP combination have been covered in release 3. The figure below shows a case that is not covered.

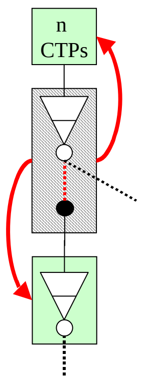


Figure 17 FTP cases not covered

This type may be detailed in later releases of the MTNM interface.

3.8 Directionality

A simple arrow symbol has been used in the document to indicate directionality of a unidirectional TP. This is shown below in Figure 18 Directionality on page 31.

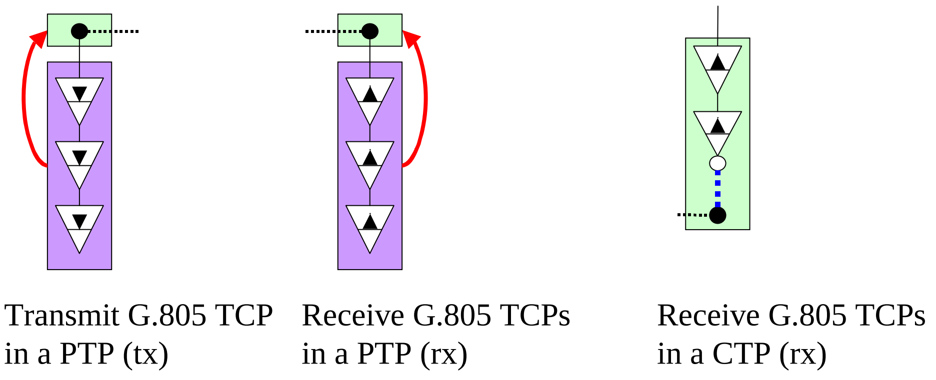


Figure 18 Directionality

The directionality of a CTP is explained in SD1-36_SNCTypes.pdf and described further in conjunction with the concept of Contra-directional flow in section 3.9.1.1 Directionality and Contra Directional flow on page 33 (see also SD1-19_LocationIdentification.pdf for an explanation of Contra Directional flow).

3.9 Monitoring

This section covers both non-intrusive monitoring where the signal is simply examined as it passes a point but is not modified in any way and tandem connection monitoring where the signal is examined and modified but the modifications are done in such a way as to be not apparent to the end termination.

3.9.1 Non-Intrusive Monitoring

An MTNM TP may incorporate capabilities for non-intrusive monitoring of contained client layers. This is shown pictorially in Figure 19 on page 32. The TP is named in the standard fashion and list all layers including those at which solely non-intrusive monitoring is carried out. As for CTPs that do not support non-intrusive monitoring, the layer of connectivity is that which names the CTP (see SD1-19_LocationIdentification.pdf for an explanation of the Contra Directional concept).

The following TP configurations could potentially support non-intrusive monitoring:

- PTP type B (not PTP type A as that has contained CTPs that are with the normal flow of traffic and any non-intrusive monitoring would be encapsulated in the CTPs). This is shown pictorially in Figure 19 Non-Intrusive Monitoring on page 32.
- Any CTP type may support non-intrusive monitoring (see section 3.6 CTP Layering on page 21):
    - For CTP type C and E the non-intrusive monitoring may occur at layers that can also be terminated. As a consequence when the Termination Mode is set to TERMINATED_AND_MAPPED the signal is terminated and there is no relevant non-intrusive monitoring. The non-intrusive monitoring is available when the Termination Mode is set to TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING.
    - For CTP type D, F, K and L, the CTP may supports non-intrusive monitoring at the client layers the Termination Mode is set as if those layers were not present from a connection perspective. For these CTPs the Termination Mode is always TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING.
- All FTP types that contain reverse direction CTPs, i.e. FTP type G-rev, H-rev, I-rev and J-rev (but not FTP type G, H, I and J as these have contained CTPs that are with the normal flow of traffic and any non-intrusive monitoring would be encapsulated in the CTPs).

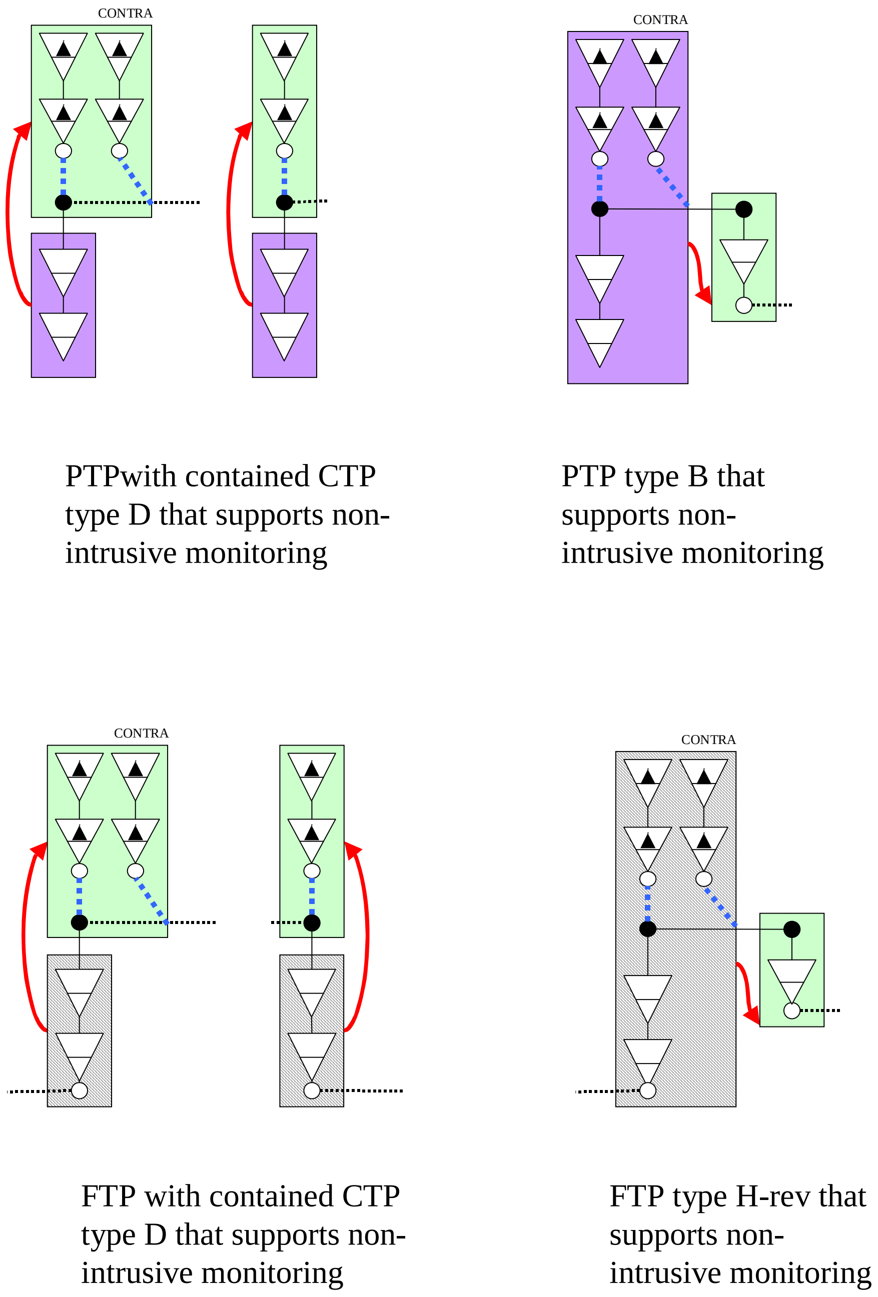


Figure 19 Non-Intrusive Monitoring

It should be noted that if basic G.805 CP level monitoring is carried out at the layer of connectivity (e.g. AIS or LOP for an SDH VC-12) the TP does not include any addition layers and does not include the G.805 TCP function (i.e. it is as shown in Figure 12 CTP variety and layering on page 23).

The following figure shows a view of a chain of NEs some of which support non-intrusive monitoring.

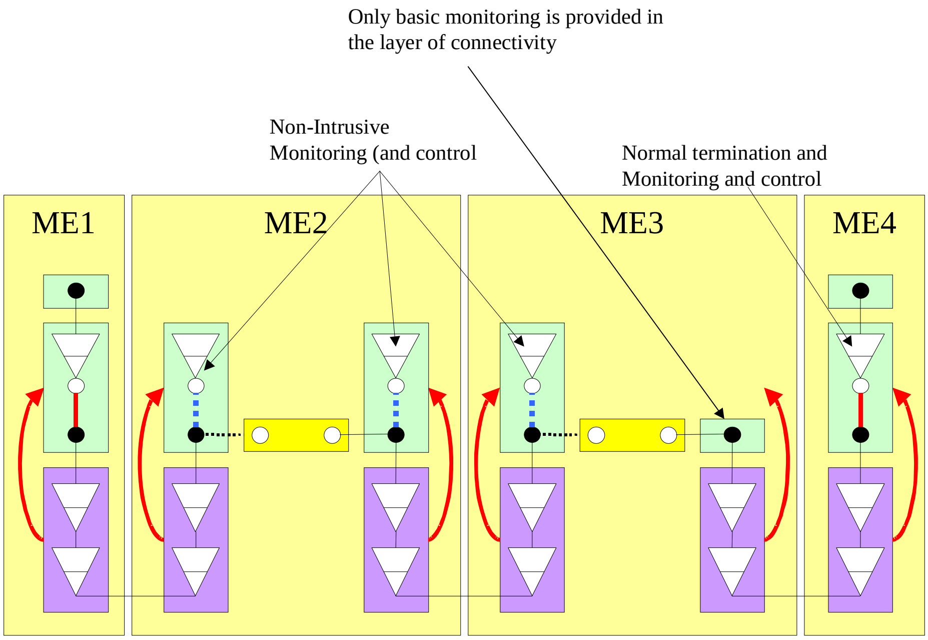


Figure 20 Non-intrusive Monitoring in a network

3.9.1.1 Directionality and Contra Directional flow

The concept of Contra Directional flow can be best explained pictorially in terms of a number of unidirectional cases (see Figure 21 CTP directionality on page 34 which highlights the CTP directionality and Figure 22 Monitor/control directionality and Contra Flow on 34 which highlights monitor and control directionality and shows Contra Flow). See also [SD1-19_LocationIdentification.pdf] for further details.

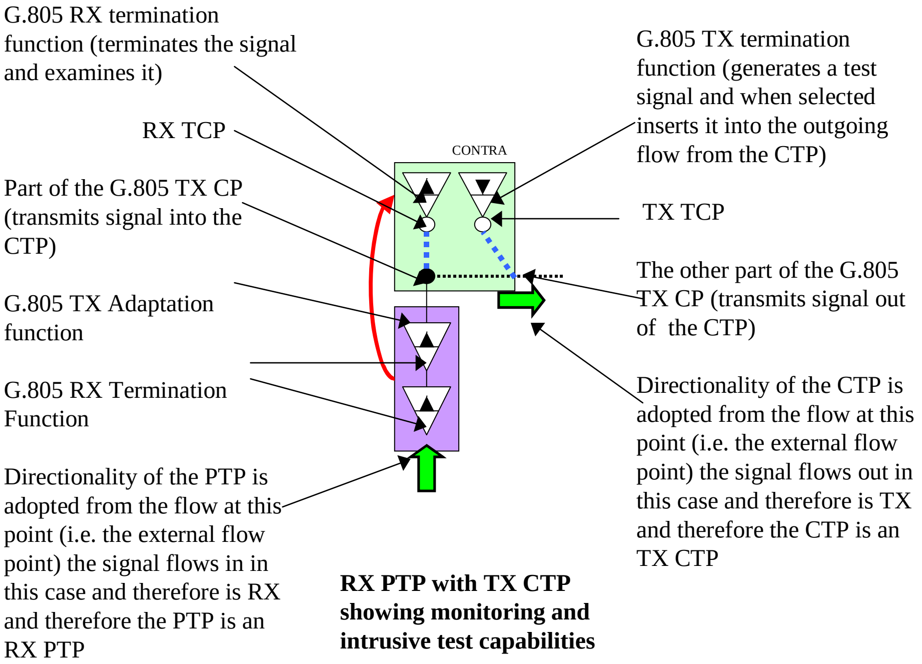


Figure 21 CTP directionality

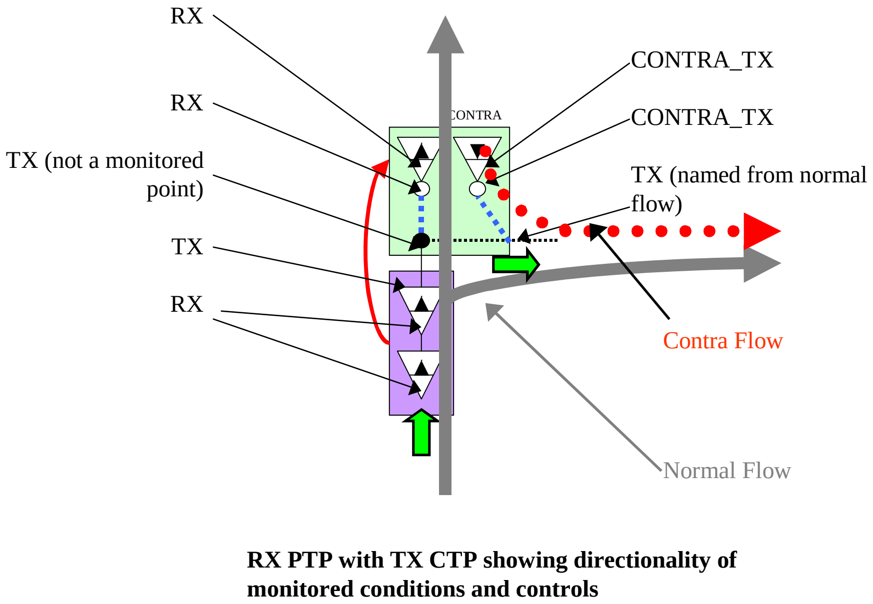


Figure 22 Monitor/control directionality and Contra Flow

3.9.2 Tandem Connection Monitoring

Tandem connection monitoring provides a capability to monitor for errors etc a subsection of a Trail potentially neither starts at nor ends at a Trail Termination. This is achieved by non-destructively adjusting the signal at selected intermediate points along the Trail and monitoring the adjusted signal at other points. This capability is modelled as a sub-layer.

The model representation trivializes the actual behaviour of the NE somewhat as the layer at which tandem connection monitoring is occurring is partially terminated and as a consequence strictly should be modelled as a full layer (with Trails of its own etc). Attributes to allow control of Tandem Connection Monitoring where that monitoring is provided as a sub-layer (as defined in ITU-T G.805) are supported via Transmission Parameters in MTNM interface version 3. Where Tandem Connection Monitoring is supported via fully defined layers layerRates have been added to the model.

It is clear that the tandem connection monitoring layers are optional layers (see also section 3.3.2 Layering Options on page 18). A representation of this capability is shown in Figure 23 Tandem Connection Monitoring on page 35.

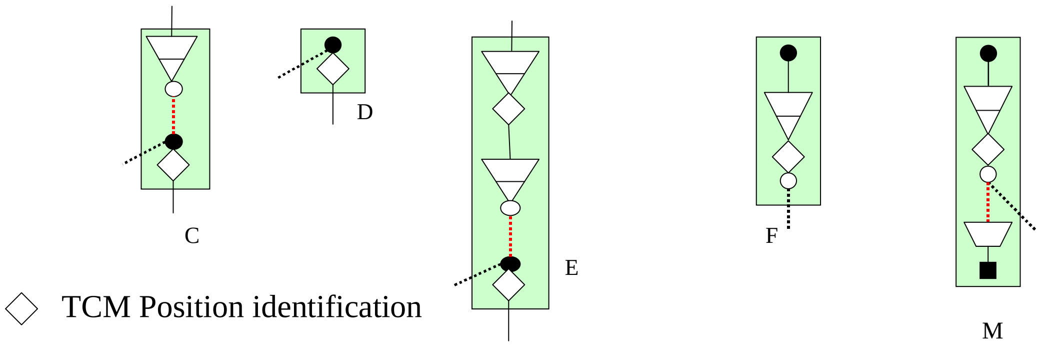


Figure 23 Tandem Connection Monitoring

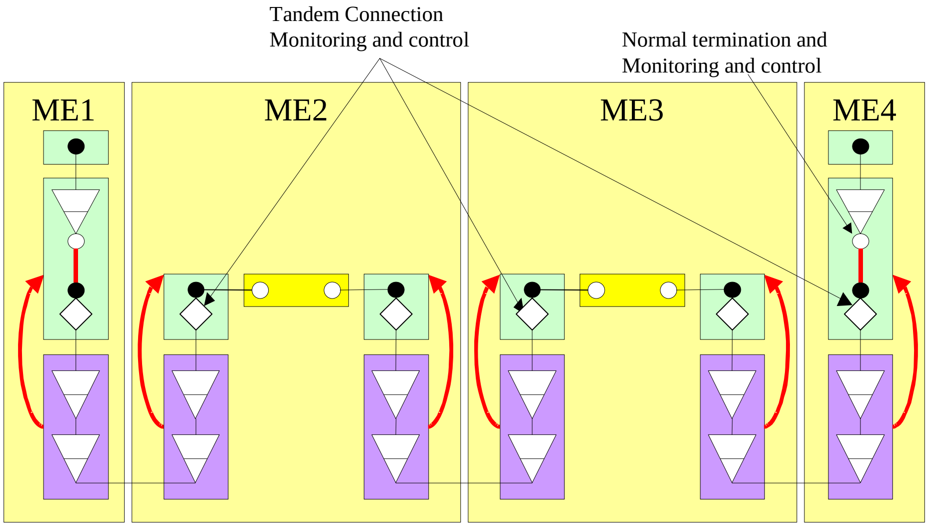
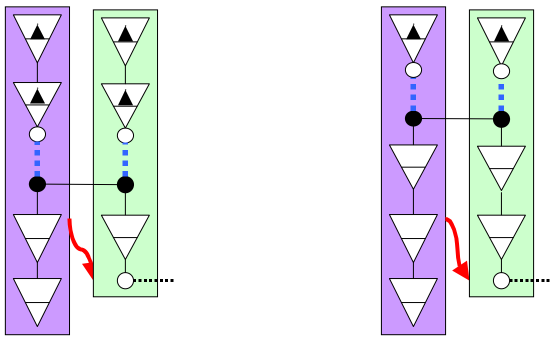


Figure 24 Non-intrusive Monitoring

3.9.3 Limitations of Monitoring in MTNM Version 3

- No control functions are provided in version 3 of MTNM to activate or deactivate the monitoring capability. It is clear that Transmission parameters positioned appropriately could be used to control the capabilities, however no specific attributes are defined beyond Tandem Connection Monitoring support.
- There is no specific support for client layer intrusive test, although it is clear that such a capability could be provided and identified in a similar way to the non-intrusive monitoring.
- Certain configurations of non-intrusive monitoring may be ambiguous. For example the configuration shown in Figure 25 Example of ambiguous cases for Non-Intrusive Monitoring on page 37 is a case where the layer lists and names of the TPs are insufficient to resolve the layer of interconnection between the two TPs.



These two configurations can not readily be distinguished using the information provided through the interface

Figure 25 Example of ambiguous cases for Non-Intrusive Monitoring

3.10 Remote Unit Encapsulations

A capability to incorporate termination functions from two geographically separate network devices within one ME. This capability is specifically directed at network deployments where there are very many simple remote network devices each of which connects back point to point to a much larger single head site device (e.g. in DSL deployments).

There are several levels of incorporation allowed:

- Equipment level incorporation: To minimize the number of MEs reported where the structure of the remote equipment is known and of relevance. The basic capability allows the incorporation at the circuit pack level so that the circuit packs of the remote network device appear to be part of the ME representing the head site device (this is covered in SD1-10_EquipmentModel.pdf).
- Termination encapsulation: To minimize the number of PTPs and CTPs reported where detailed management of the remote termination functionality is required but the structure of the remote equipment is not known or not relevant. The capability allows for the incorporation of the termination functions of the remote device to be modelled encapsulated in the PTP/CTP/FTPs of the head site. This case is covered in the following section.

So as to avoid confusion a simple diagram has been included to assist the reader in distinguishing between “far end” data and “remote unit” data (see Figure 26 “Far End” and “Remote Unit” compared on page 38.

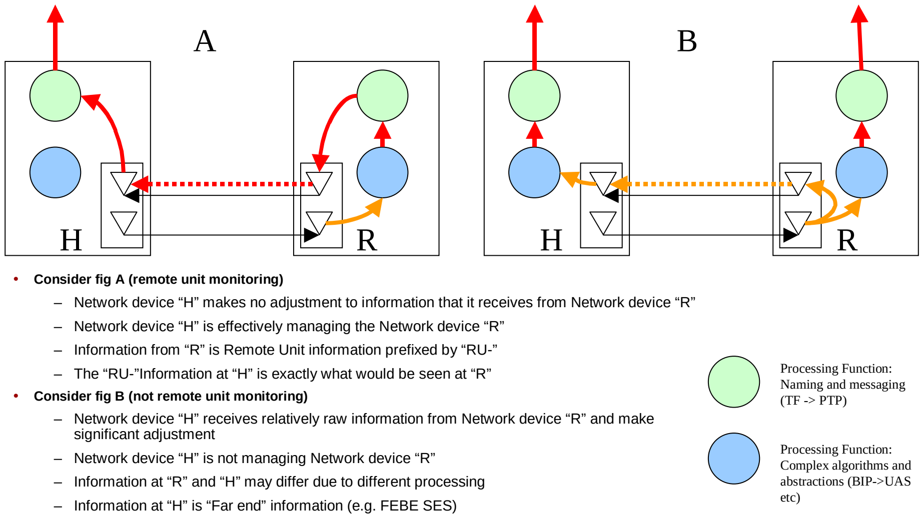


Figure 26 "Far End" and "Remote Unit" compared

3.10.1 Deployment Constraints for TP Encapsulation

The only case supported it that of a remote device port that is unprotected and connects to a single head site port. The modelling eliminates the need for topological links and remote ME modelling.

3.10.2 Basic Encapsulations

The basic encapsulation of Remote Unit TPs is shown in Figure 27 Basic RU PTPs and CTPs on page 39. This is further depicted using the equipment oriented representation in Figure 28 Physical view of Remote unit model on page 39. The key observations are that:

- A single PTP is reported that includes both the local and remote termination functions
- Each CTP identified represents both the local and remote functions. The CTPs are contained in the PTP in the normal fashion
- An SNC may not connect to the remote side of the CTP
- The case shown is symmetrical such that at both ends of the link:
    - the layers terminated are the same
    - the flexibility of the layers is the same
    - the encapsulations of TPs would be the same when modelling the end in isolation

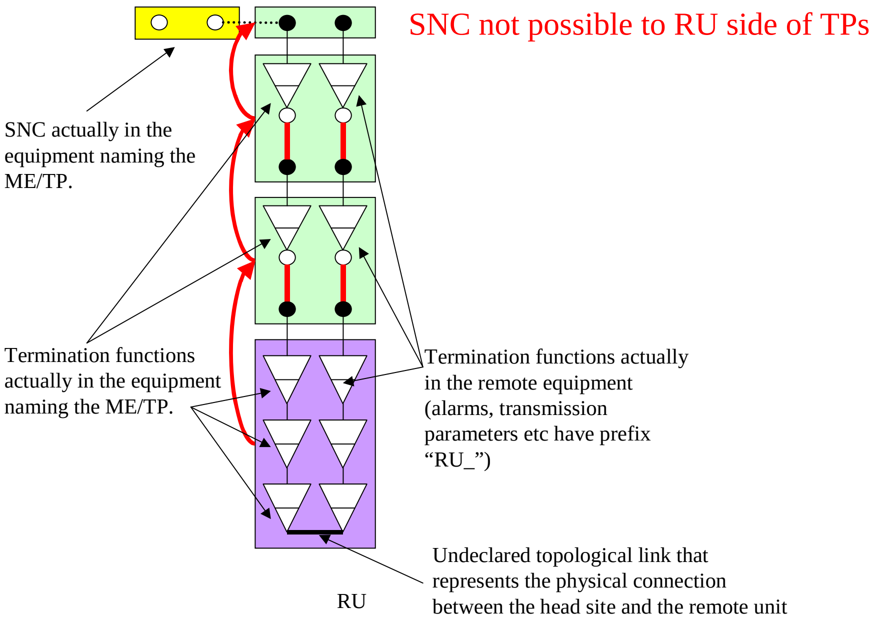


Figure 27 Basic RU PTPs and CTPs

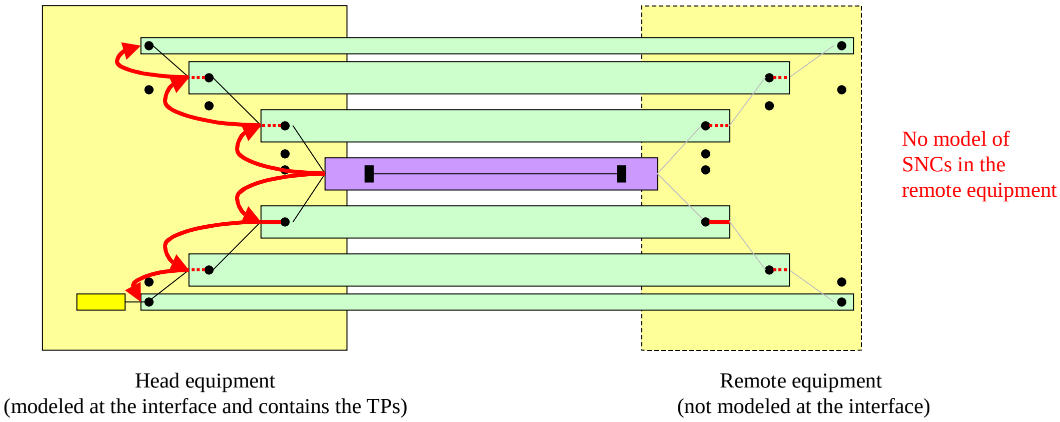


Figure 28 Physical view of Remote unit model

Asymmetric cases have not be covered in this release so combinations of ports that have different termination capability or support different layer mappings is not defined.

3.10.3 Non-Intrusive Monitoring

It is possible to represent non-intrusive monitoring and contra-directional non-intrusive monitoring using the techniques identified in section 3.9 Monitoring on page 31. This is show in Figure 29 RU PTPs and RU/ Non-intrusive monitoring CTPs on page 40.

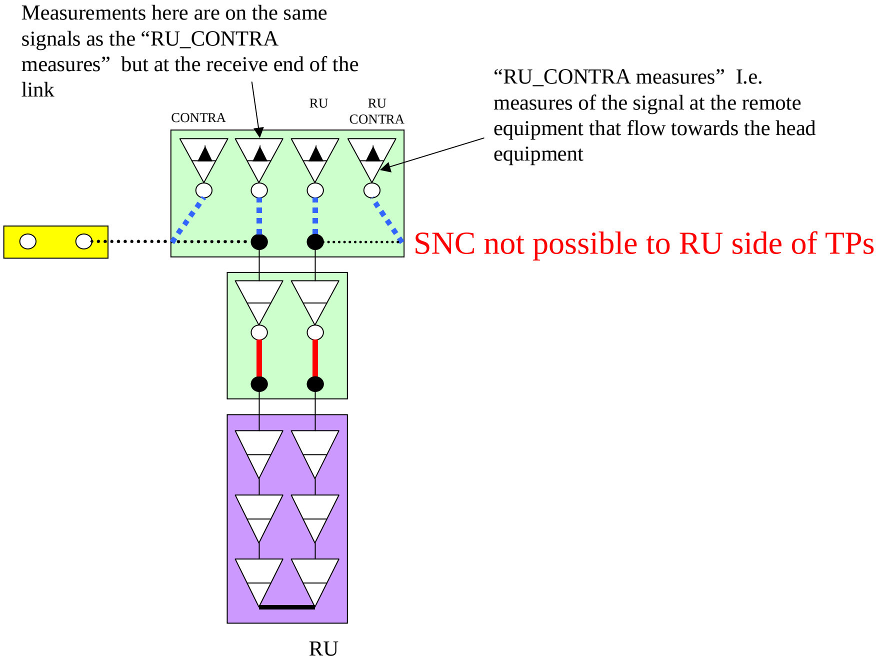


Figure 29 RU PTPs and RU/ Non-intrusive monitoring CTPs

3.11 Building PTPs, FTPs and CTPs

3.11.1 Rules for CTP break out

The following sections identify the reasons for breaking a multilayered TP.

3.11.1.1 Point where cardinality increases

Where the number of traffic flows on one side of an adaptation function is greater than one there will be a boundary in the encapsulation of layers and on the side where there is greater than one traffic flow there will be many potential CTPs. These CTPs will be contained in the naming TP of the signal flow (PPT or FTP). This will occur as a result of either multiplexing or inverse multiplexing. From the perspective of the flow of signal there may be many levels of multiplexing or inverse multiplexing and these may be contained in a single naming TP but encapsulated in separate TPs. This is shown in Figure 30 Break in Encapsulation due to Cardinality Change on page 41.

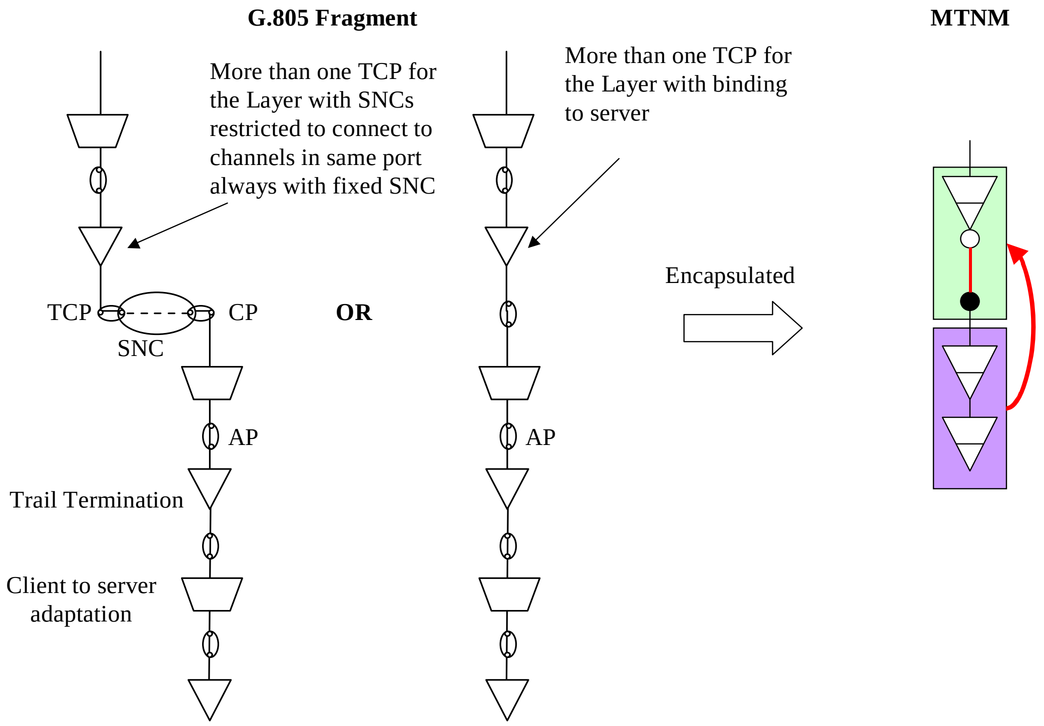


Figure 30 Break in Encapsulation due to Cardinality Change

3.11.1.2 Point of optional connection flexibility

Where there is a point of optional connection flexibility where the point may be connected to other points in the NE on flows associated with other ports then at this point there will be a boundary in the encapsulation of layers and the point of connection flexibility will be encapsulated in a CTP. This is shown in Figure 31 Break in Encapsulation due to connection flexibility on page 42

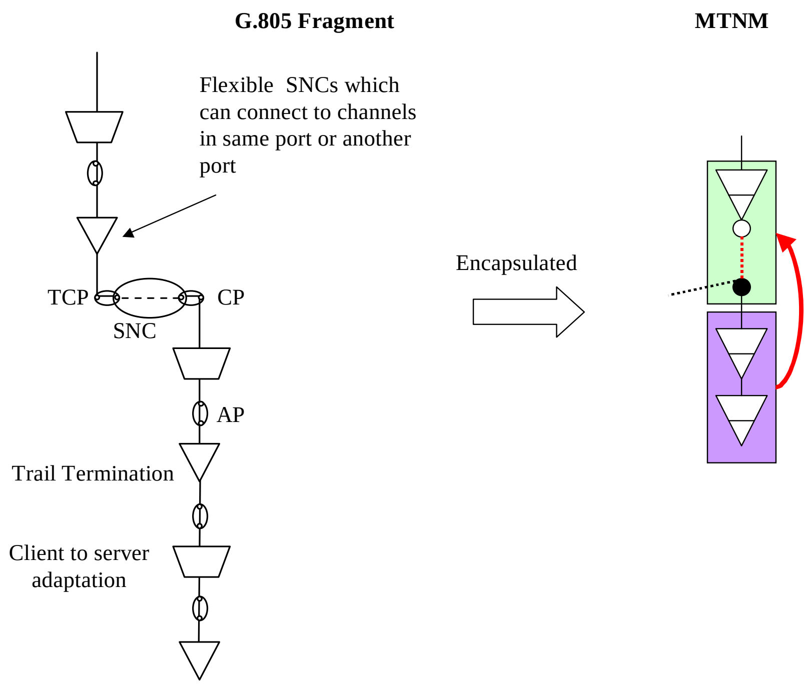


Figure 31 Break in Encapsulation due to connection flexibility

3.11.1.3 Point of Transition from demultiplexing to multiplexing (point of reversal of layering)

Whist following the flow of a signal through from layer to layer starting at a physical port a point may be reached where the flow transitions from multiplexing to demultiplexing prior to reaching a point of connection flexibility or a point where the cardinality increases. At this point there will be a boundary in the encapsulation of layers and following layers will be encapsulated in a CTP. This also applies to the case of an FTP, however it tends to intertwine with other rules so will be explained separately (see section 3.11.3 FTP Models on page 43). Various reverse layer cases are highlighted in section 3.11.4.2 Layering and Reverse Layers on page 46.

3.11.2 Rules for breaking flow containment

Although the previous sections will solve a vast majority of cases, in some cases the model that results will still be unwieldy or ambiguous. To overcome this rules have been set out below that break long chains of containment and these rules should also be applied.

3.11.2.1 Inflexible NE

In some simple NEs it is possible that there are no points of connection flexibility that would cause the chain of TPs linked back to a naming TP to be broken prior to reaching the next physical port.

In these cases the flow should be broken at the point of transition from multiplexing to demultiplexing (point of layer reversal) and this break in flow is a break in naming. The two resulting CTPs at either side of the point of inversion (each contained in its own PTP) should be connected by a fixed SNC or crossconnect. (also see section 5 Fixed Crossconnect Usage on page 94).

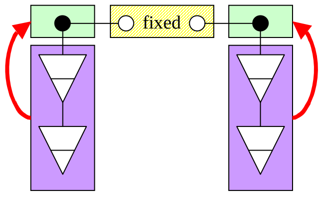


Figure 32 Simple Inflexible NE

3.11.2.2 Sequence of points of reversal in inflexible NE

If there are multiple reversals of adaptation in an inflexible NE then there will be a need to break the flow in several places and incorporate several fixed crossconnects and FTPs.

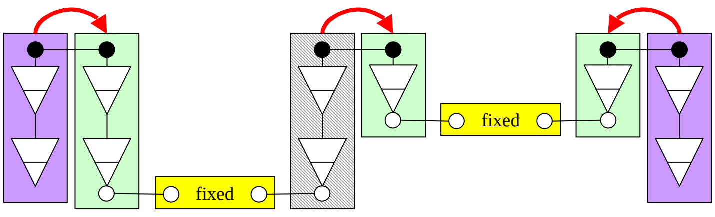


Figure 33 Repeated reversal of layers

3.11.3 FTP Models

As noted in section 3.1.2 Floating Termination Point on page 13, an FTP is used where a set of termination points within an equipment can not be related by permanent traffic flow to a physical port. As identified in section 3.7 FTP Layering on page 27 an FTP may contain CTPs on both the client and server side. To determine what is encapsulated in the FTP and what is encapsulated in the CTPs that are contained the following rules may be applied.

3.11.3.1 Basic FTP Rule

The base layer of an FTP should be the one below which there either are no contained (server) CTPs or are more than one contained (server) CTP directly associated to the FTP (the case of inverse multiplexing). It is not allowed for there to be a single CTP contained on the server side of an FTP, where no connection flexibility, as the TPs of that CTP must form part of the FTP. The examples in Figure 34 Positioning the FTP where there is cardinality and connection flexibility variety on page 44 show a number of cases of FTP CTP relationship.

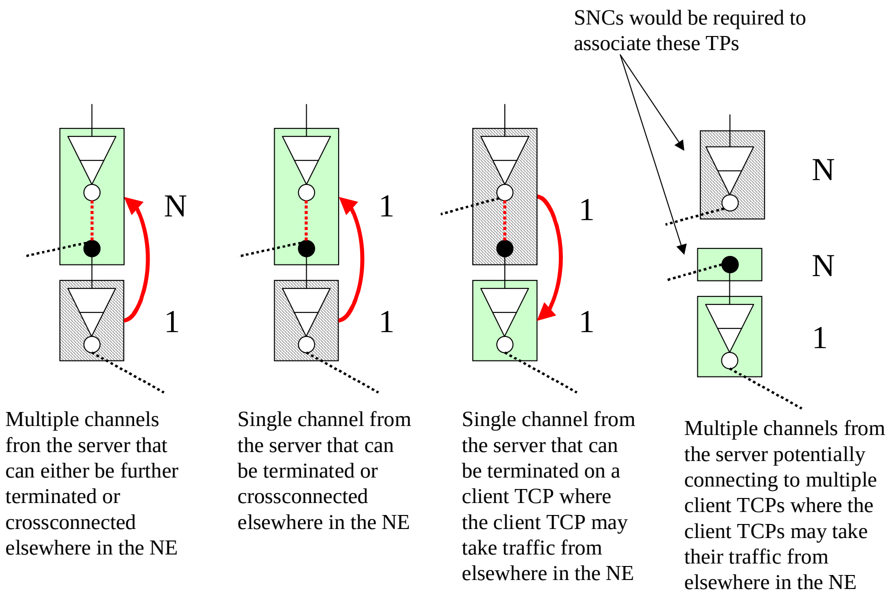


Figure 34 Positioning the FTP where there is cardinality and connection flexibility variety

3.11.3.2 Symmetrical FTP Configurations

Where there are floating terminations that relate by a reversal of layering it is not always clear what FTP containments should be chosen. Some cases are shown in Figure 35 Ambiguous FTP cases on 45. It is assumed to be unlikely that such cases are encountered in current equipment designs. However, if such a case is encountered it is suggested that layer count asymmetry should be used to identify the FTP so an FTP should contain more layers than a CTP and if there is no asymmetry then the EMS should consistently report the FTP-CTP relationships based upon some internal deterministic rule so that the arrangements of TPs do not change through power cycles etc.

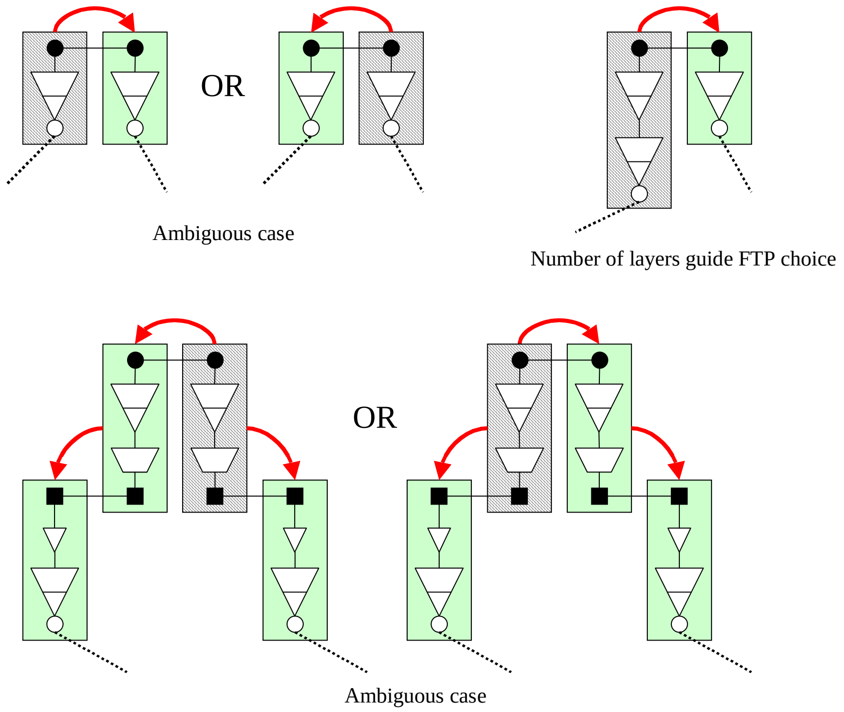


Figure 35 Ambiguous FTP cases

3.11.4 Basic Assembly

This section describes some basic assemblies of PTPs, CTPs and FTPs in more detail as a lead into the detailed examples in the later sections.

3.11.4.1 Symbol Key

The symbols used through out this document are introduced and defined in earlier sections. For figure component definitions/explanations refer to Figure 2 MTNM and G.805 Layered Model on page 12, Figure 3 MTNM and G.805 Layered Model on page 14, Figure 12 CTP variety and layering on page 23, Figure 18 Directionality on page 31 and Figure 19 Non-Intrusive Monitoring on page 32.

3.11.4.2 Layering and Reverse Layers

This section identifies the layers within each of the TPs when related by reverse layer relationships.

- "same orientation client containment"
- "reverse orientation client containment"
- "same orientation server containment"
- "reverse orientation server containment"

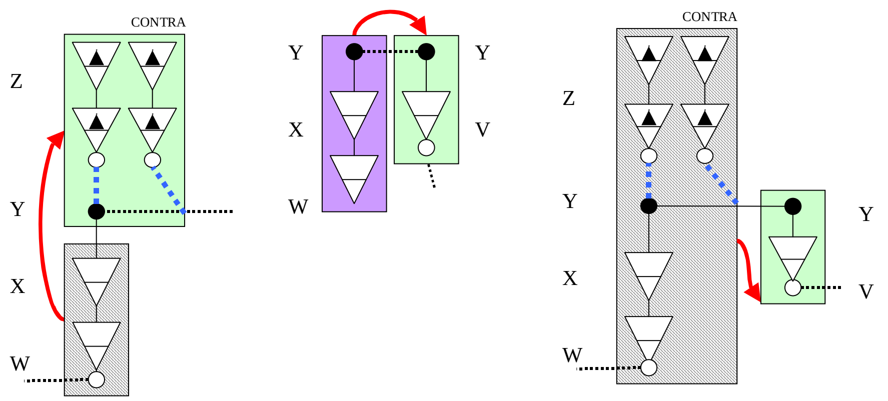


Figure 36 Layering

3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA

The functional modelling concepts of MTNM interface are based on ITU-T Recs. G.805 and G.852.2 but extend the layering concepts set out there using multi-layer encapsulations identified from real network element behaviour to provide performance advantage for information transfer between over the interface.

In the G.805 client/server relationship of adjacent (single-)layer networks, client layer link connections are supported by server layer trails (one-to-one, many-to-one, one-to-many) through an adaptation that modifies the characteristic information of the client layer so that it can be transported over the trail (a connection with trail terminations at both ends) in the server layer network. A one-to-one client/server relationship represents the case of a single client layer link connection supported by a single server layer trail.

The many-to-one relationship represents the case of several link connections of client layer networks supported by one server layer trail at the same time. Multiplexing techniques are used to combine the client layer signals. The one-to-many relationship represents the case of a client layer link connection supported by several server layer trails in parallel.

Unlike traditional multiplexing (as described above), inverse multiplexing techniques are used to distribute the client layer signal over many lower rate server signals.

The inclusion of inverse multiplexing as well as adaptation and trail termination function cardinalities (and also link partitioning) are the essential enhancements of the current issue of G.805 (March 2000, published in August 2001) compared to its predecessor (November 1995).

This document uses the term “Fragmentation” to indicate an inverse multiplexing adaptation applied to a given data signal.

Each example of inverse multiplexing represent a specific kind of "fragmentation" of a signal into a number of lower rate components signals (`LR_Fragment`) that are then passed across a number of parallel lower rate servers, i.e. an inverse multiplexing adaptation to some signal. These fragments are then recombined at the receive end to reform the original signal.

There are several different mapping techniques that are used to allow generation of a recombinable signal. These techniques include some general and some technology-specific approaches (e.g., G.7042 LCAS, I.761 IMA). Transmission parameters are used to specify controls etc for inverse multiplexing (these are specified in the supporting document SD1-16_LayeredParameters.pdf).

The fragmentation mechanism for SONET, SDH and DWDM is called Virtual Concatenation. Virtual Concatenation is specified in T1.105 (T1X1.5) document for SONET technology and by ITU-T SG15 for SDH technology. Currently there is a proposal from in T1X1.5 group to provide specific extensions to G.709 to incorporate the Virtual Concatenation function to the ODUk layer of Digital Wrapper technology.

The fragmentation mechanism for ATM is called Inverse Multiplexing (IMA) for ATM technology. IMA is a User-to-Network Interface standard first approved by the ATM Forum in 1997.

There are several generalized structures that should be used in the construction of Inverse Multiplex models, these are shown in Figure 37 Inverse Multiplexing Key models 47.

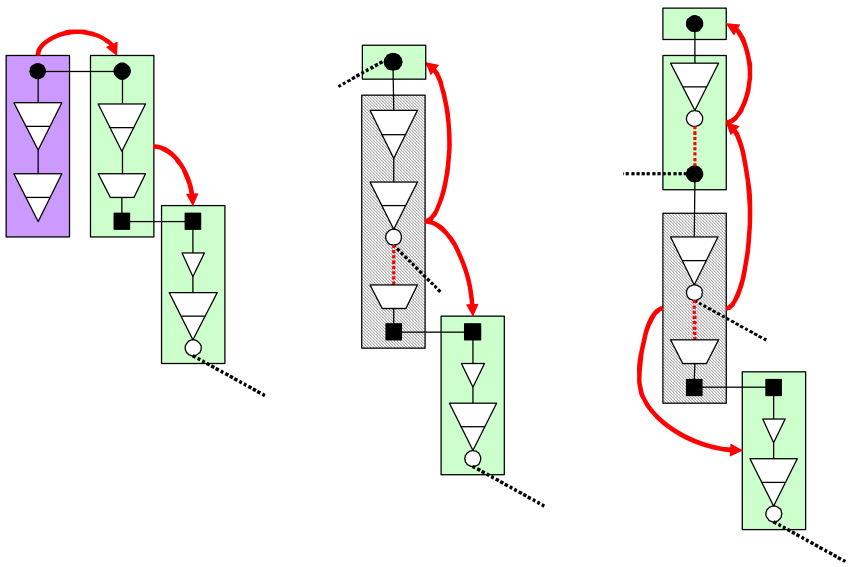


Figure 37 Inverse Multiplexing Key models

These models are used as the basis for the specific examples highlighted in the following sections.

3.12 CTP Naming Summary

The CTP name includes a reference to layer (see supporting document SD1-25_objectNaming.pdf). The layer to be included is identified as “Naming layer” in Figure 38 CTP connection layers, naming and terminationMode on page 48. As for all TPs, where a CTP encapsulates multiple layers, the layers should be listed in the Layered Transmission Parameters (see 3.1.1 Basic Modelling Concepts on page 11) in order from the lowest in the diagram to the highest (i.e. X, Y, Z).

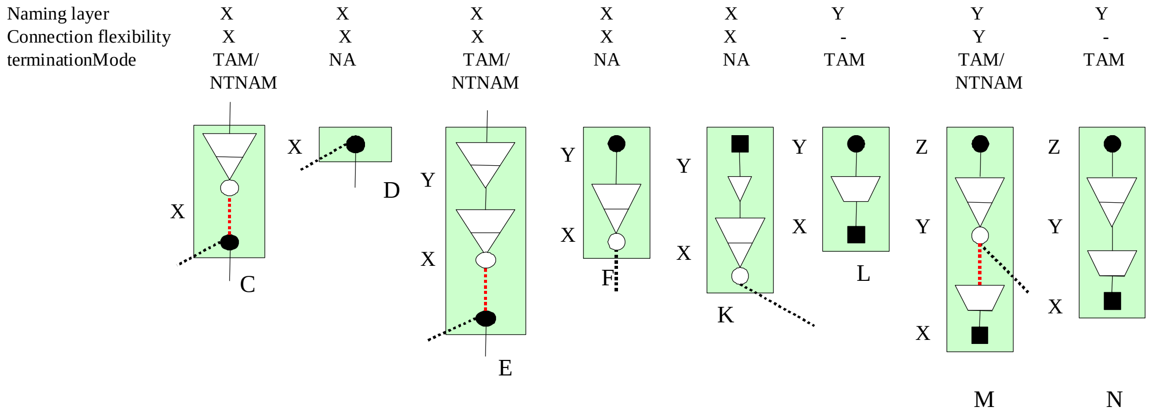


Figure 38 CTP connection layers, naming and terminationMode

3.13 Layer equivalence for interconnection compatibility

To allow for inter-TP connectivity (either with SNCs or Topological Links) and for end-to-end trail validation all specific DSR layerRates (e.g. LR_DSR_OC12_STM4) are compatible with and equivalent to LR_DIGITAL_SIGNAL_RATE (which is the non-specific rate).

3.14 Repeating Layers in a TP

This consideration appears only relevant to the DSR layer at this release, however is generalisable to other layers assuming that they should have the appropriate characteristics.

It is allowed to repeat a layer in a TP if that indeed reflects the multiplexing of the TP. It is clearly possible to have two instances of DSR layer in a TP structure:

- A DSR layer should be present where there is a serialisable electrical signal (e.g. RS but not VC4)
- There may be more than one DSR exposed in a TP where this is necessary to explain compatibility with other interconnected (or interconnectable) ports in a network where the serialisable signal may be exposed
- Where there is a single DSR layers it may be optionally specific or general
- Where there are multiple DSR layers encapsulated in a single TP only one occurence may be general LR_DIGITAL_SIGNAL_RATE and all must have different specific DSR layer rates so that they can be distinguished from each other (e.g. LR_DSR_OC12_STM4).

Refer to section 8.2.14 Repeated DSR layer in a single TP in an OTN Network on page 124 for a network perspective.

4 SPECIFIC CASES OF TP LAYERING

4.1 Overview

To further clarify the usage of layering in the TP this section identifies the expected layering for several comply found port types. This is by no means a restrictive list and the set of layers will clearly vary from technology to technology and new TP examples will regularly be encountered.

To allow the NML to interpret inter-port compatibility, the TPs of the types identified below must be represented with the layers identified. It should be noted that although the list of layers are in order of position in the multiplexing hierarchy, there is no intended list order meaning in the interface and the EML may report the layers of a TP in any order.

The following sections detail the layers for various basic port types.

4.2 STM-n/OC-n Port in SDH, SONET, WDM and ATM NEs

4.2.1 Digital Signal Rate

The digital signal rate represents the first layer of adaptation from an optical signal to an electrical signal. The format of the signal is usually decided by the framing available on the client signals and that is used to represent the first layer of electrical signal formats in this model. The Digital Signal Rate is qualified via the format known to the EMS/NE. If the format is not known at the configuration time, no qualification is provided.

The STM-n (OC-3n) Loss of Signals are raised against this rate.

4.2.2 Non-Coloured STM-4 port

The following diagram shows the layers of an STM-4 port that is capable of terminating VC4 and can provide VC12 and VC3 payload. The port shown can not map to VC2. It does not use a specific wavelength (uses "dark fiber").

To make the VC12 and VC3 CTPs available for connectivity the NML would use set TerminationMode attribute of a VC4 CTP to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING. When set to this value the VC4 CTP is no longer available for connection at the VC4 rate.

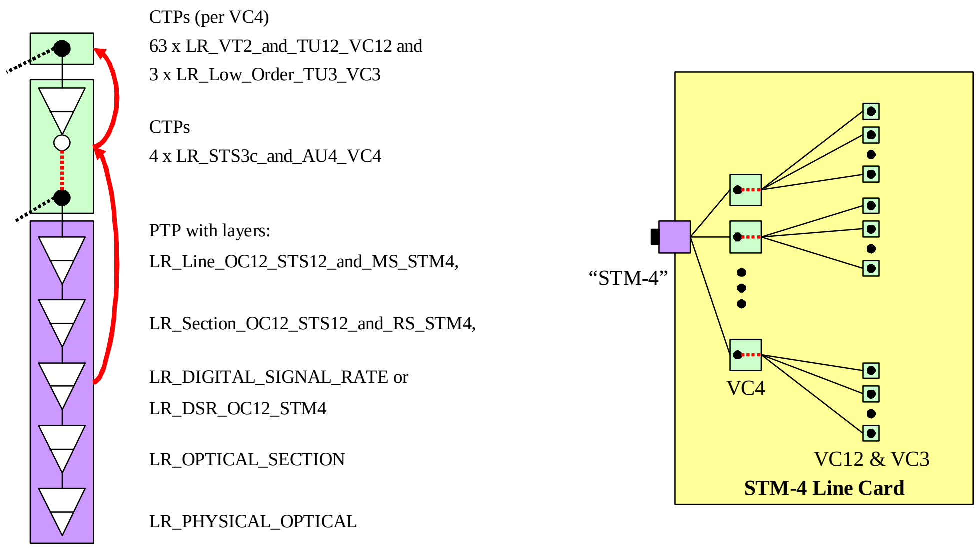


Figure 39 Non-Coloured STM-4 Port

4.2.3 DWDM capable OC12 port

The following diagram shows the layers of an OC12 port that is capable of terminating STS1 and can provide VT1.5. The port is DWDM capable, i.e., it can process the OTS/OMS overhead. The optical layer model is consistent with that described in ITU-T G.872[5].

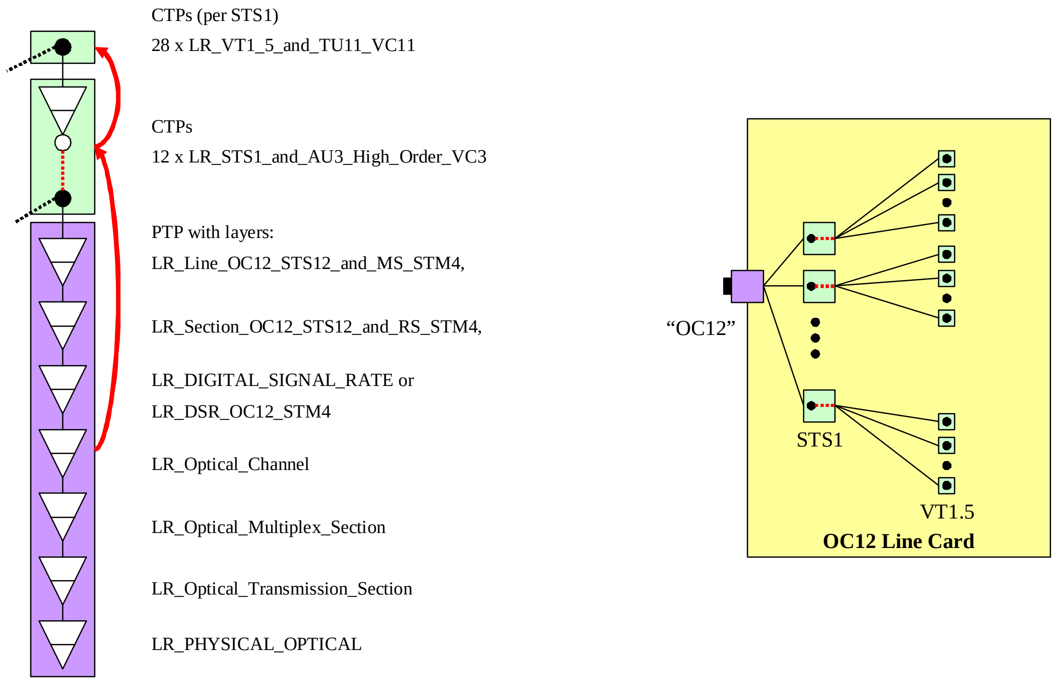


Figure 40 DWDM OC12 Port

5 It should be noted that the optical layer has been modelled with only a single OMS and also only a single layer to represent optical channels.

4.2.4 Coloured STM-4 port

The following diagram shows the layers of an STM-4 port that is capable of terminating VC4 and can provide VC12 and VC3 payload. The port shown can not map to VC2. It uses a specific wavelength (coloured fiber), but is not DWDM capable (it does not process the OTS/OMS overhead).

To make the VC12 and VC3 CTPs available for connectivity the NML would use set TerminationMode attribute of a VC4 CTP to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING. When set to this value the VC4 CTP is no longer available for connection at the VC4 rate.

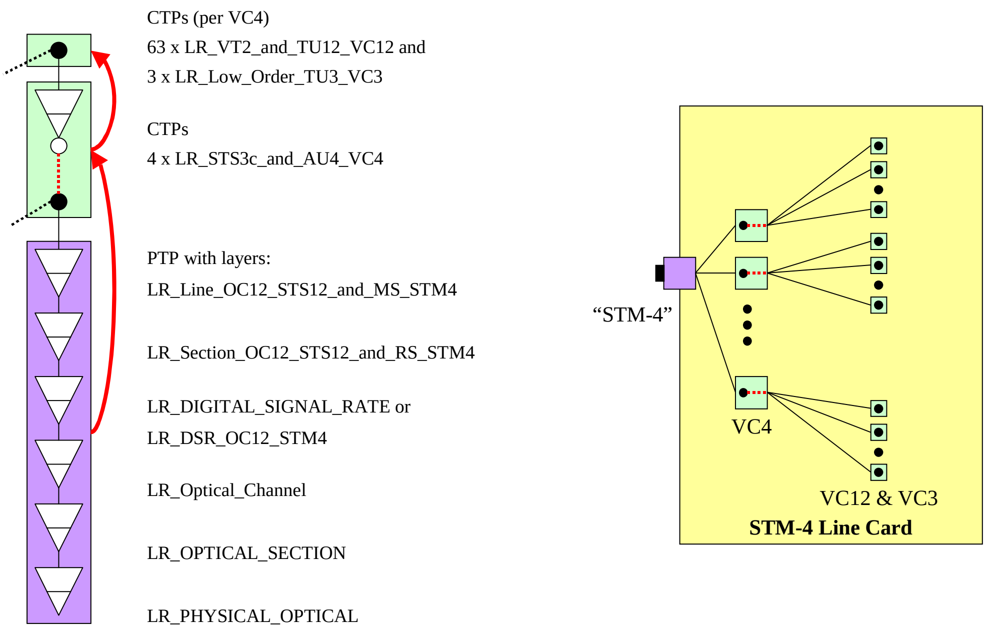


Figure 41 Coloured STM-4 Port

The following diagram shows a coloured STM-4 port with the additional OTN layers referenced in section 3.2 Optical Layer Encapsulation on page 15.

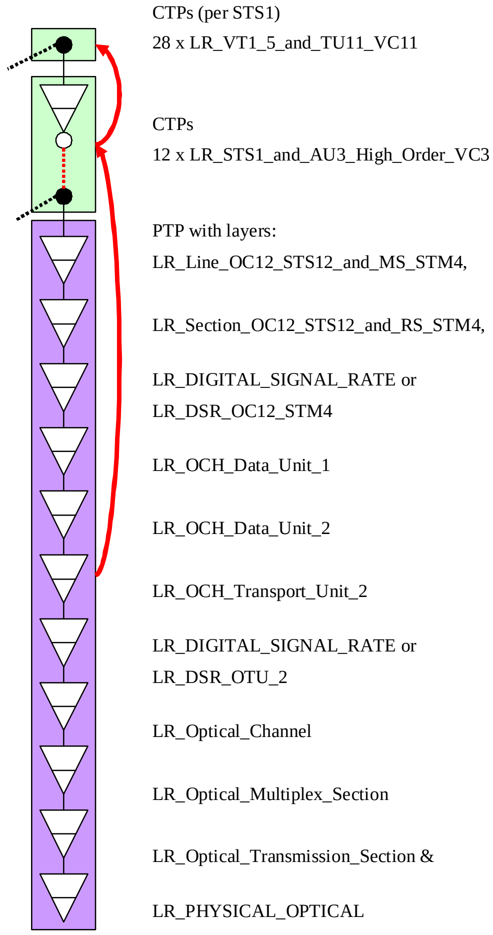


Figure 42 Coloured STM-4 Port exposing full OTN model

4.2.5 Non-Coloured OC48 port

The following diagram shows the layers of an OC48 port that is capable of terminating STS1 and can provide VT1.5. The port can also crossconnect at the STS3c and STS12c rates.

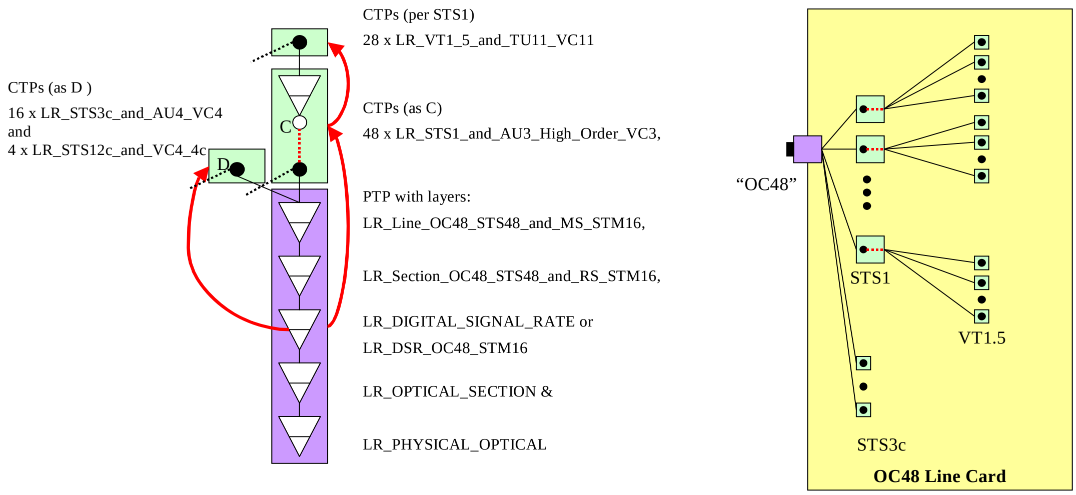


Figure 43 Non-Coloured OC48 Port

4.2.6 ATM capable STM-4 ports

The following diagram shows the layers of an STM-4 port that always terminates all four VC4s to provide ATM NI. The ATM NI can itself be terminated to provide ATM VP CTPs (notice that the ATM NI can not be crossconnected). The ATM VP can be crossconnected or further terminated to provide ATM VC CTPs.

Termination mode is used to set the TPs to terminate and to make the client CTPs available for connectivity (TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING). When setting the TP to terminate parameters such as traffic descriptor identifiers can be provided.

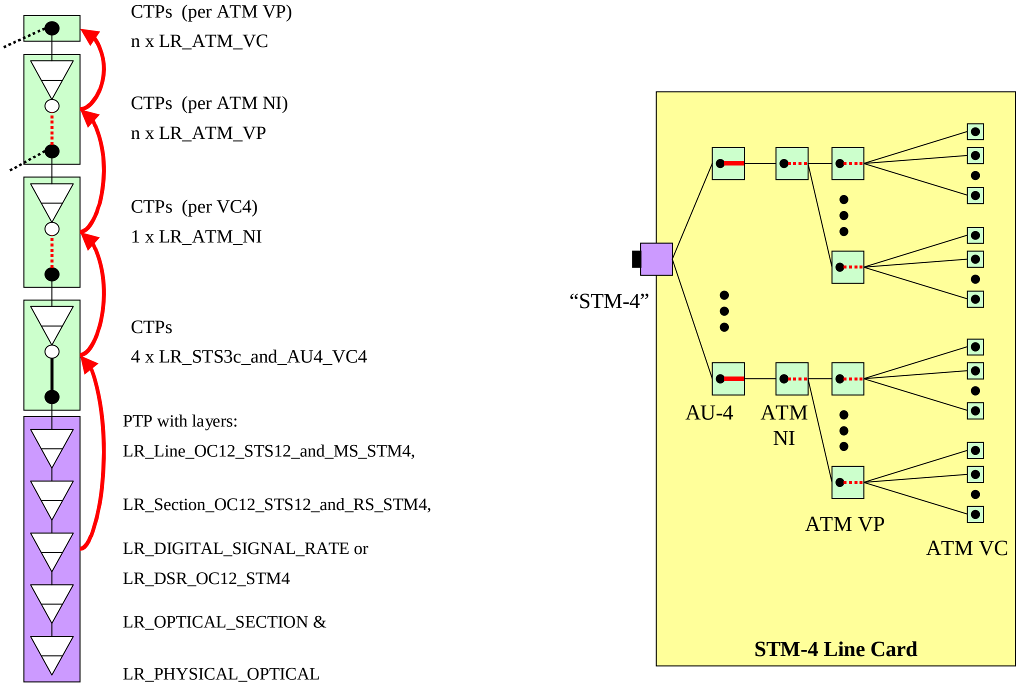


Figure 44 ATM Capable STM-4 Port

4.2.7 ATM and SDH capable STM-4 port

The following diagram shows the layers of an STM-4 port that is capable of terminating VC4 and can provide VC12, VC3 and ATM NI from the VC4. The ATM NI can itself be terminated to provide ATM VP CTPs (notice that the ATM NI can not be crossconnected). The ATM VP can be crossconnected or further terminated to provide ATM VC CTPs.

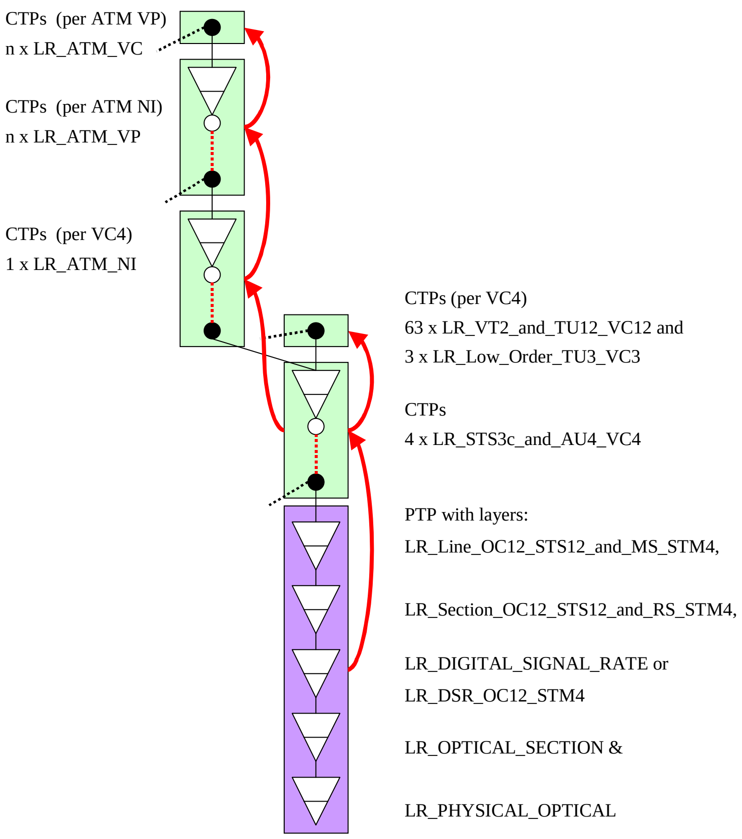


Figure 45 ATM and SDH Capable STM-4 Port

4.2.8 Mixed Async (PDH) and SONET Port

The following diagram shows the layers of an OC12 port that is capable of terminating STS1 from which it can provide DS1 for crossconnection via two different mappings. The naming of the CTPs allows the client to distinguish the specific mapping chosen.

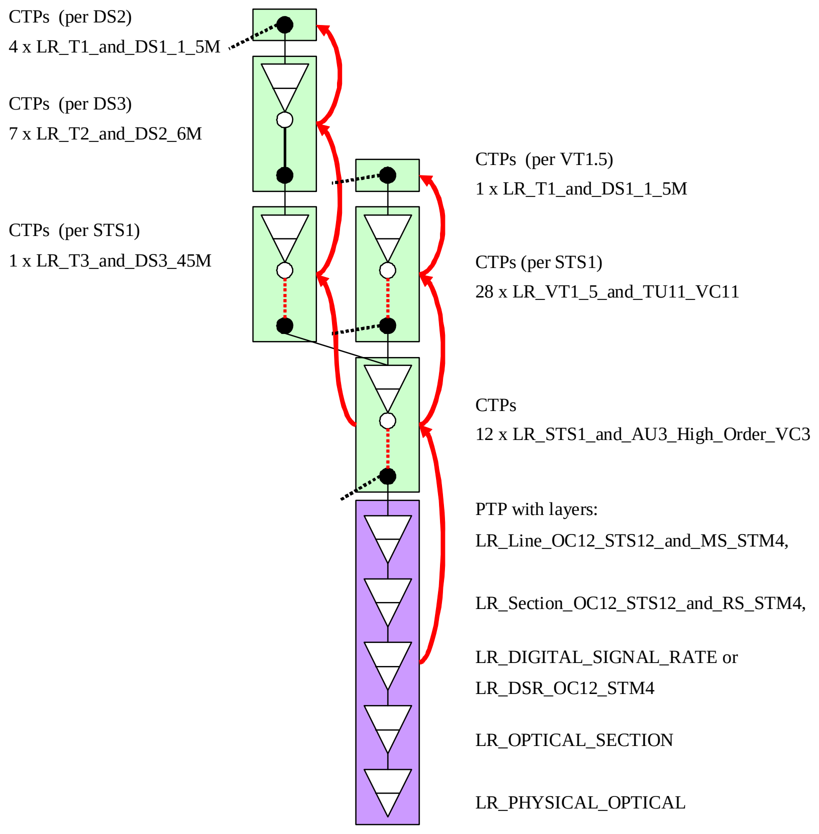


Figure 46 Mixed Async (PDH) and SONET OC12 Port

4.2.9 STM-4 port showing VC12 path overhead monitors

The following diagram shows the layers of an STM-4 port that is capable of terminating VC-4 and can provide VC12 payload. The VC12 CTP is capable of monitoring the overhead of the received signal[6]. Note that the VC12 CTP does not contain any CTPs. The TerminationMode of the VC12 CTP always takes the value TM_NEITHER_TERMINATED_NOR_AVAILABLE_FOR_MAPPING and as a consequence the CTP behaves in the same way as CTP D in Figure 12 (on page 23).

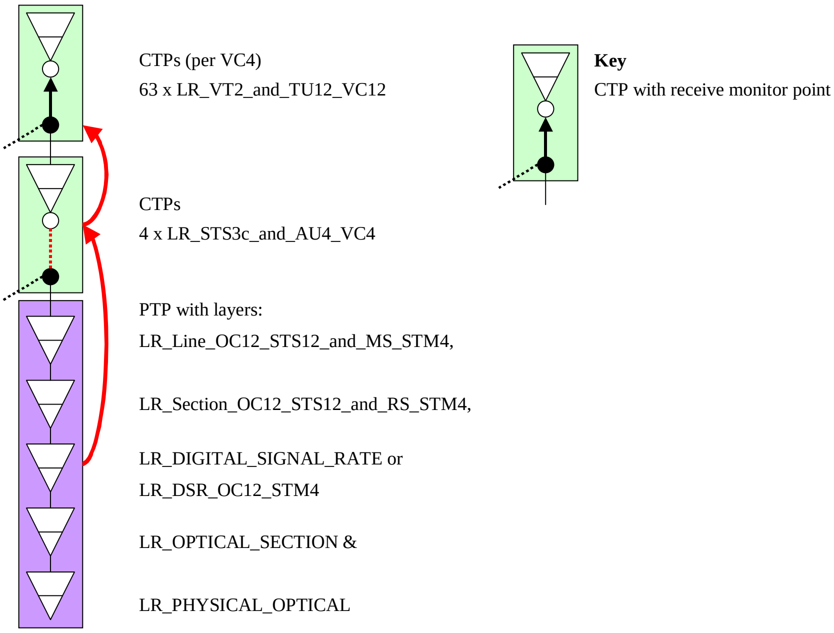


Figure 47 STM-4 Port with VC12 Overhead Monitoring

[6] This model mechanism can also be used for Tandem Connection monitoring (and the equivalent DWDM connection monitoring), although the specific usage of the interface needs to be defined further.

4.2.10 Mixed Async and SONET port that is ATM and DWDM capable

As discussed previously...

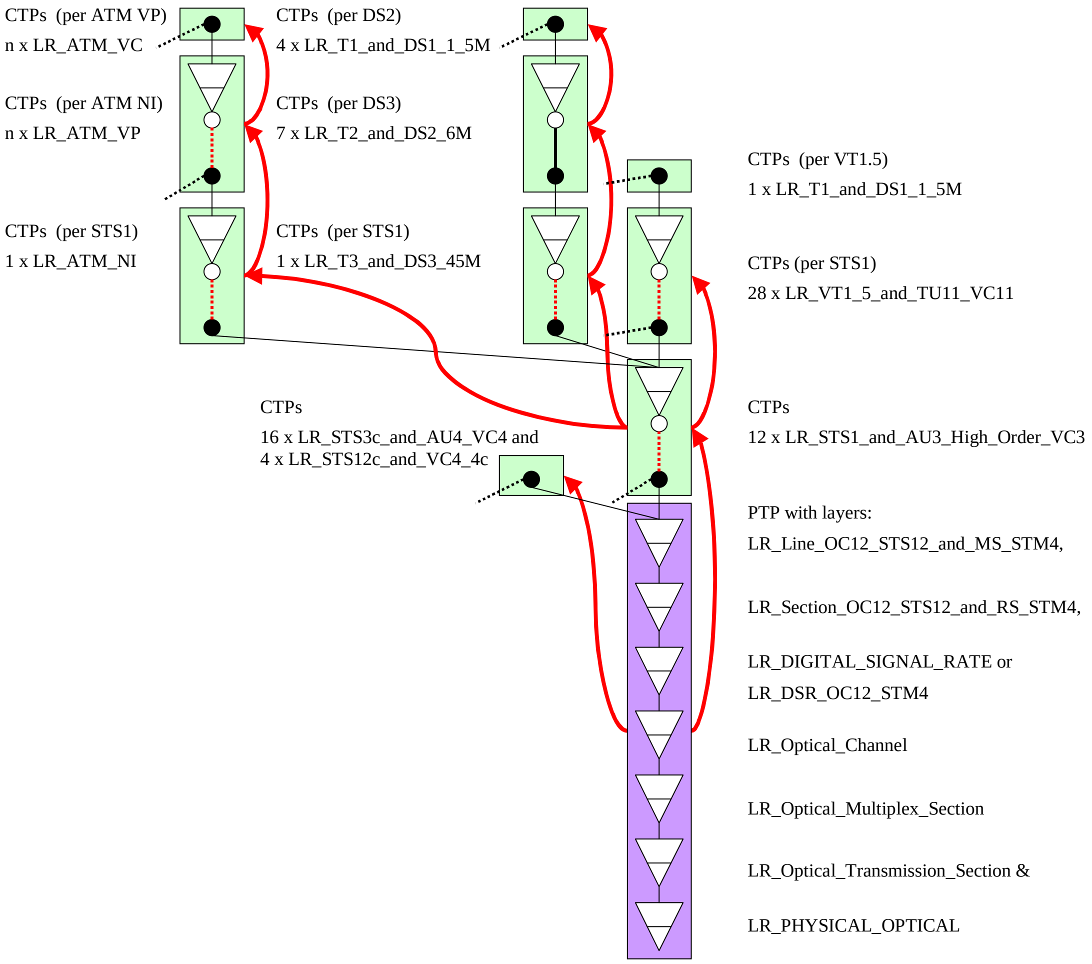


Figure 48 DWDM, ATM, Async and SONET Port

4.2.11 G.709 transponder port

The following diagram shows the layers of Transponder port that takes an STM16 signal from a non-coloured port and packages it in a G.709 ODU1 container for transport across a WDM network.

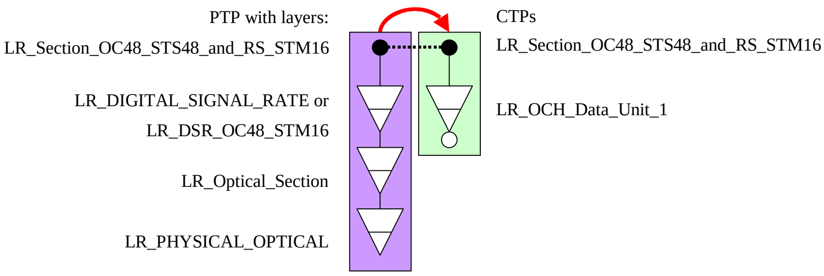


Figure 49 G.709 Transponder port

4.2.12 OTS port supporting G.709 DSR, ODU and OTU

The following diagram shows the model of a port that maps multiple unspecified digital signals into OTU/ODUs and then each is mapped into a single wavelength. All wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

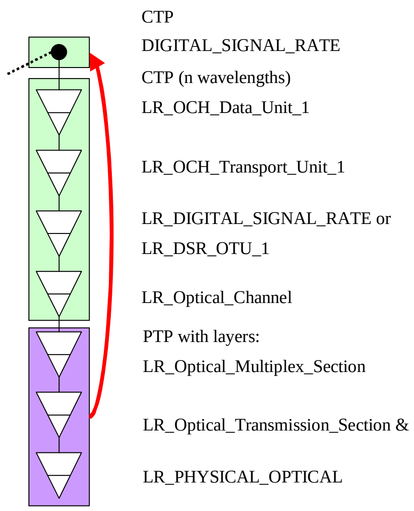


Figure 50 G.709 OTS port

4.2.13 OTS port supporting G.709 OTU and ODU

The following diagram shows the model of a port that maps multiple ODU into a single physical port. The port takes each ODU signal and multiplex it into an OTU and then each is mapped into a single wavelength. All wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

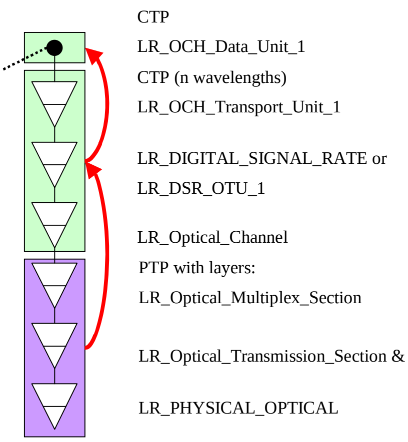


Figure 51 G.709 OTS port

4.2.14 OTS port supporting G.709 ODU1, ODU2 and OTU2

The following diagram shows the model of a port that maps multiple ODU1 into a single physical port via OTU2. The port takes each ODU1 signal and multiplex it into an ODU2 then an OTU and then each is mapped into a single wavelength. All wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

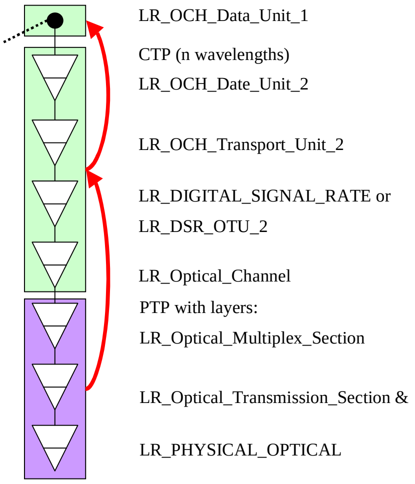


Figure 52 G.709 OTS port with ODU2/1

4.2.15 OTS port supporting G.709 ODU1, ODU2 and OTU2

The following diagram shows the model of a port that maps multiple ODU1 into a single physical port via OTU2. The port takes each ODU1 signal and multiplex it into an ODU2, then for this case there is ODU2 connection flexibility. As a consequence of the connection flexibility at both ODU1 and ODU2 layers an FTP has been used in the model. The ODU 2 is then mapped into an OTU and then each OTU is mapped into a single wavelength. All wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

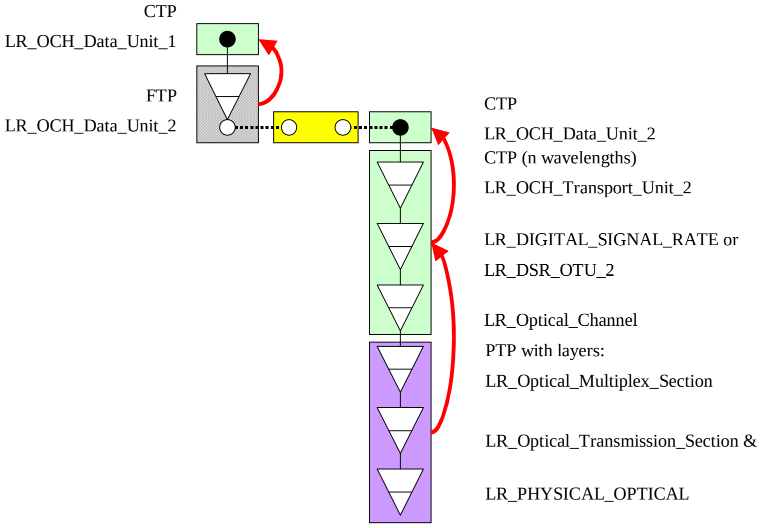


Figure 53 G.709 OTS port with ODU2/1 with flexible ODU2 connection

4.2.16 OTS port supporting G.709 ODU1, ODU2 and OTU2

The following diagram shows the model of a port that maps multiple ODU1 into a single physical port via OTU2. The port takes each ODU1 signal and multiplex it into an ODU2 or takes an ODU2 signal from elsewhere in the ME and then maps the ODU2 into an OTU and then each OTU is mapped into a single wavelength. All wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

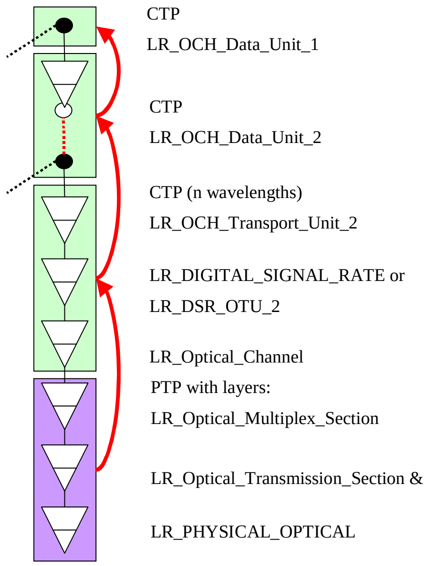


Figure 54 G.709 OTS port with ODU2/1 with flexible ODU2 connection

4.2.17 OTS port supporting G.709 ODU1, ODU2 and OTU2 showing connected trib

The following diagram shows the model of two ports in an ME.

The WDM port that maps multiple ODU1 into a single physical port via OTU2. The port takes each ODU1 signal and multiplex it into an ODU2 or takes an ODU2 signal from elsewhere in the ME (in this case the terminationMode of the ODU CTP is also set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING so that the client ODU1 can be connected). The ODU2 is then mapped into an OTU which is the mapped into a single wavelength. As this is a multiple wavelength port all wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

The diagram also shows a DSR tributary port that carries an unspecified signal and maps it into an ODU1. The two ports are shown connected.

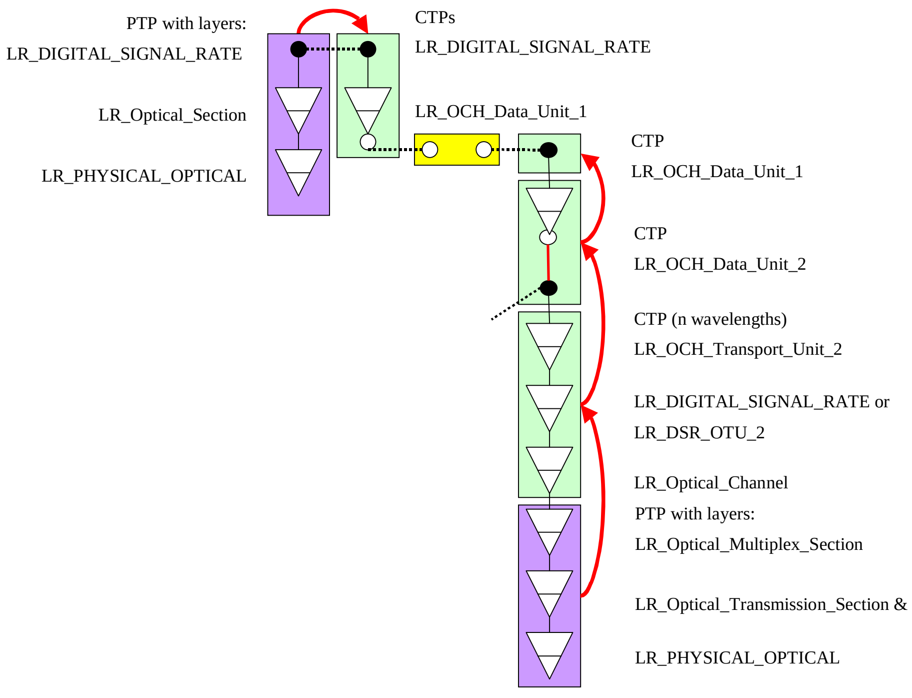


Figure 55 ME with G.709 OTS port and DSR tributary port

The following diagram shows a case with a more specific digital signal.

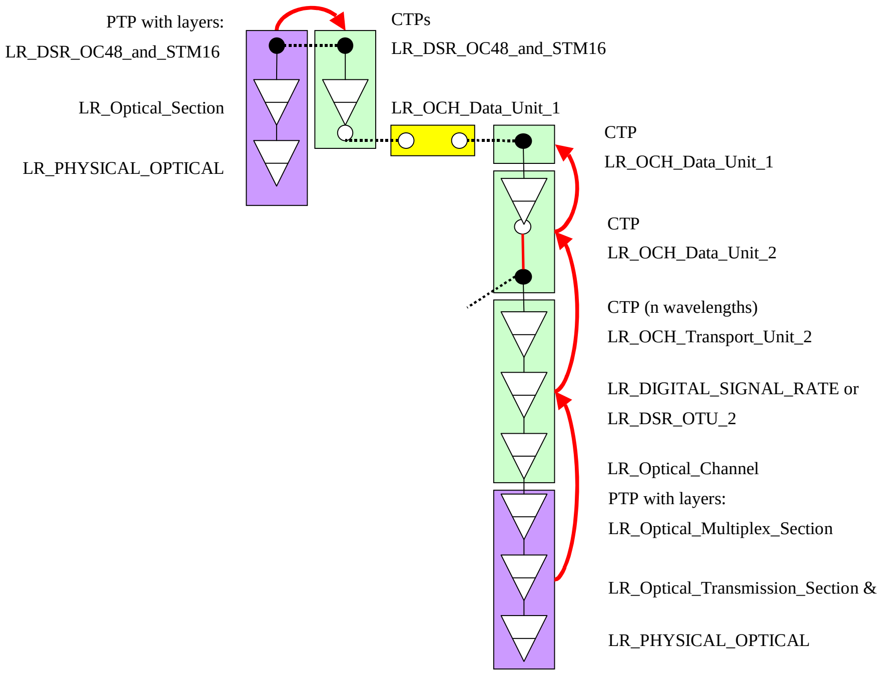


Figure 56 ME with G.709 OTS port and specific DSR tributary

4.2.18 OTS port supporting G.709 ODU1, ODU2 and OTU2 showing connected trib

The following diagram shows the model of two ports in an ME.

The WDM port that maps multiple ODU1 into a single physical port via OTU2. The port takes each ODU1 signal and multiplex it into an ODU2 or takes an ODU2 signal from elsewhere in the ME (in this case the terminationMode of the ODU CTP is also set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING so that the client ODU1 can be connected). The ODU2 is then mapped into an OTU which is the mapped into a single wavelength. As this is a multiple wavelength port all wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

The diagram also shows an OC48/STM16 tributary port that maps the OC48 section via a DSR into an ODU1. The two ports are shown connected.

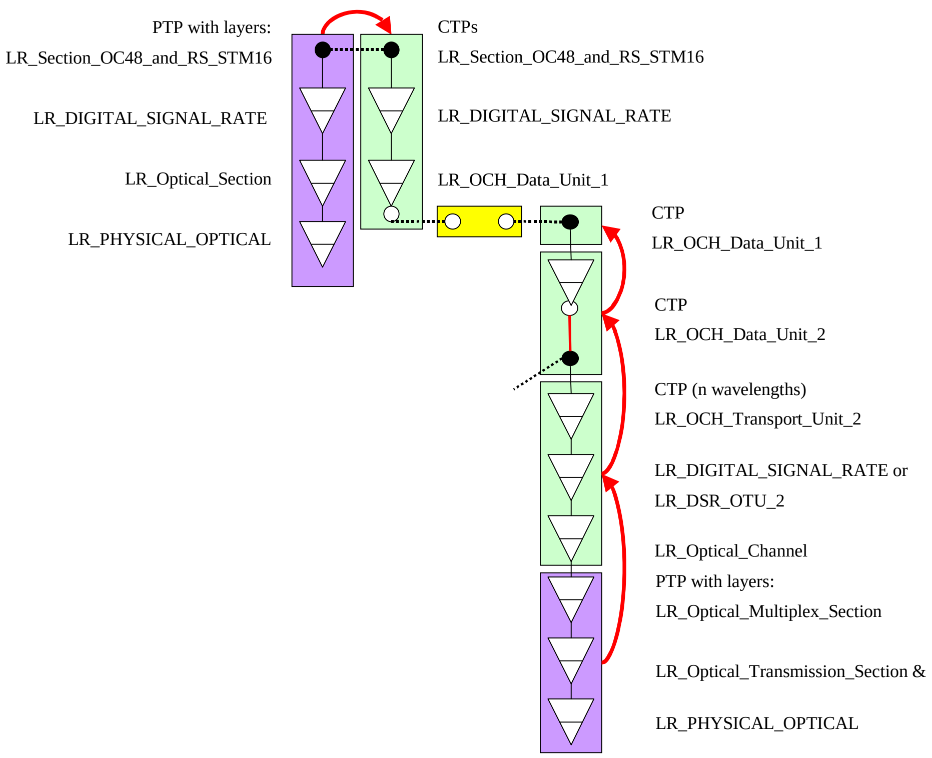


Figure 57 G.709 OTS port with ODU2/1 with flexible ODU2 connection with OC48 payload

4.2.19 Basic coloured WDM port showing connected trib

The following diagram shows the model of two ports in an ME.

The WDM port that maps multiple unspecified digital signals into a single physical port via a basic OCH layer. The port takes each DSR signal and multiplex it into an OCH (a single wavelength). As this is a multiple wavelength port all wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

The diagram also shows a DSR tributary port that carries an unspecified signal. The two ports are shown connected.

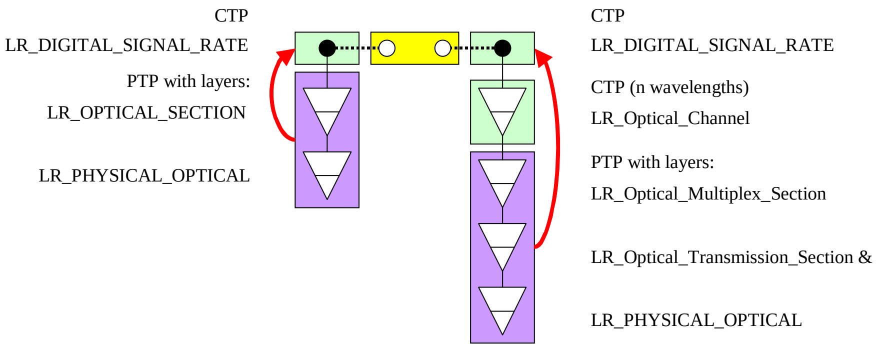


Figure 58 Coloured to non-coloured

4.2.20 OTS port supporting G.709 ODU1, ODU2 and OTU2 showing connected trib

The following diagram shows the model of two ports in an ME.

The WDM port that maps multiple ODU1 into a single physical port via OTU2. The port takes each ODU1 signal and multiplex it into an ODU2 or takes an ODU2 signal from elsewhere in the ME (in this case the terminationMode of the ODU CTP is also set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING so that the client ODU1 can be connected). The ODU2 is then mapped into an OTU which is the mapped into a single wavelength. As this is a multiple wavelength port all wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

The diagram also shows an OC48/STM16 tributary port that decomposes to VC4 via standard mappings. In this case the ME offers VC4 connection flexibility as well as ODU1 connection flexibility. As a consequence the mapping between the VC4 and the ODU1 is supported by an FTP. The two PTPs are shown connected via the FTP and SNCs at the VC4 and ODU1 layers.

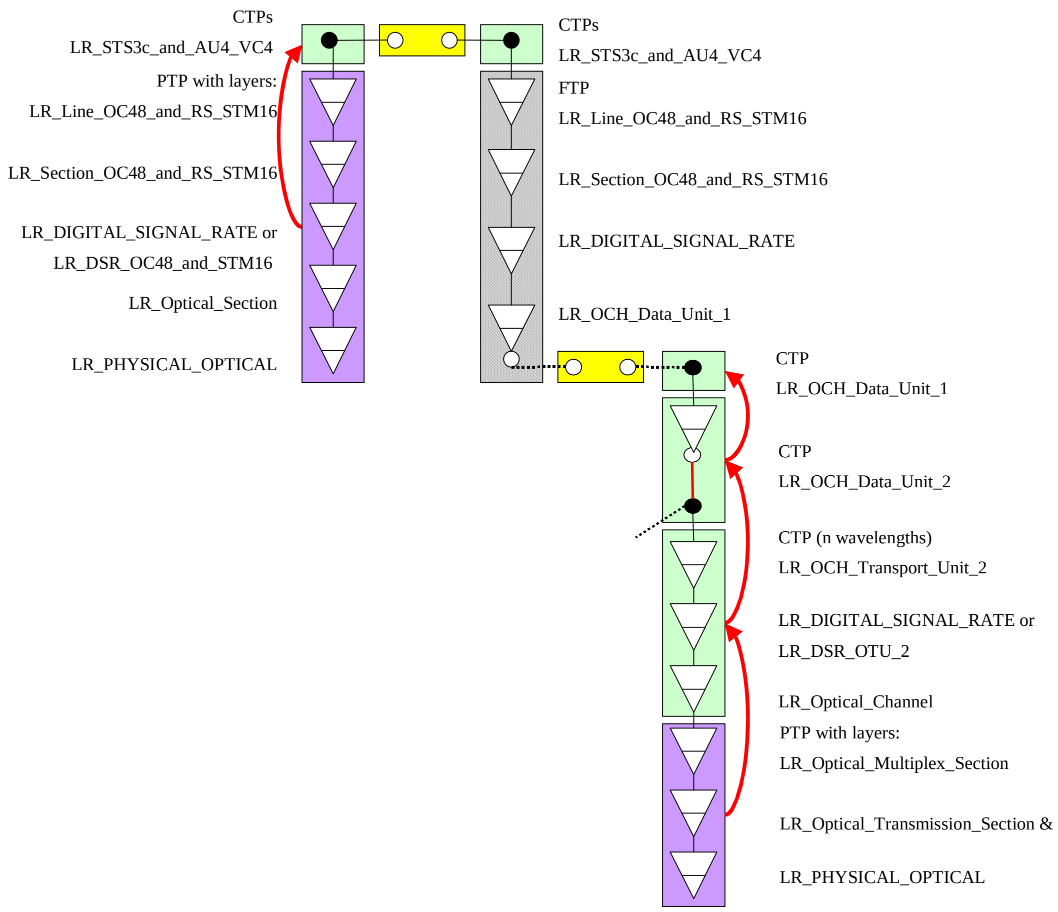


Figure 59 G.709 OTS port with ODU2/1 with flexible ODU1 connection with VC4 payload

4.2.21 Basic coloured WDM port showing connected OC48 trib

The following diagram shows the model of two ports in an ME.

The WDM port that maps multiple OC48/STM16 signals into a single physical port via a basic OCH layer. The port takes each OC48/STM16 signal and multiplex it via a DSR layer into an OCH (a single wavelength). As this is a multiple wavelength port all wavelengths are then mapped into a single OMS. As there is no flexibility in the OCH layer, the CTP terminationMode is always set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING.

The diagram also shows an OC48 tributary port. The two ports are shown connected.

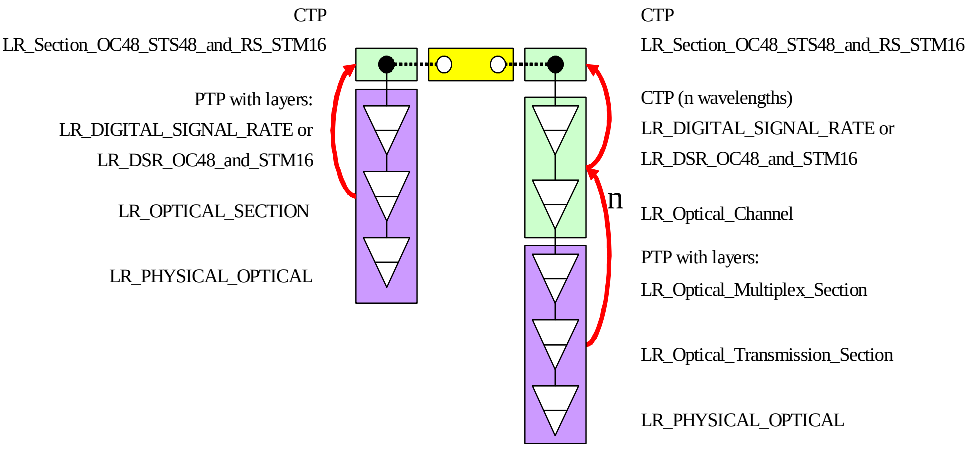


Figure 60 Basic WDM mux terminating multiple Optical Channels connecting at OC48/STM16

4.3 Async and PDH ports in SDH, SONET, DWDM and ATM NEs

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section.

4.3.1 DS3 trib port of an SONET NE

The DS3 port modelled below has no internal flexibility, the electrical signal is terminated to provide the DS3 signal which is mapped into the STS1 unterminated. The figure shows both a G.805 view and an equipment oriented view[7]. The termination mode of the CTP always takes the value TM_NA (see 3.6.2 (on page 24)).

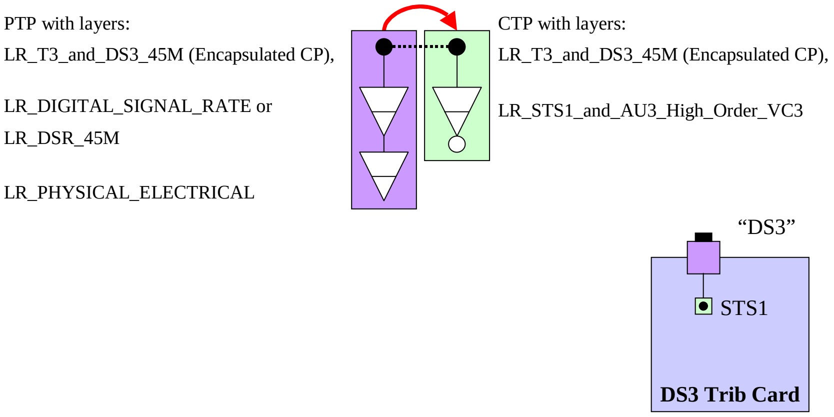


Figure 61 DS3 Trib Port

4.3.2 DS1 trib port of an SDH NE

The DS1 port modelled below has no internal flexibility, the electrical signal is terminated to provide the DS1 signal which is mapped into the VC12 unterminated. This figure shows the special mapping of DS1 into a TU12 for propagation across an SDH network[8]. The termination mode of the CTP always takes the value TM_NA (see 3.6.2 (on page 24)).

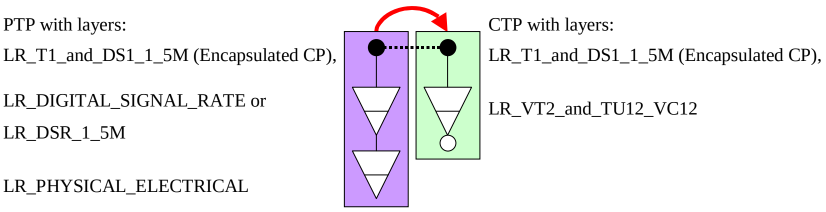


Figure 62 DS1 Trib Port in an SDH NE

[7] No other equipment oriented examples are provided at this stage as the relationship between the G.805 view and the equipment view is the same as this example for all following examples.

[8] Strictly the DS1 is mapped into a VC11 which is carried in a TU12, however, in the MTNM model, it is assumed that the VC11 and VC12 are equivalent in this case and the model shows DS1 mapped into VC12.

4.3.3 DS3 trib circuit emulation port of an ATM NE

The DS3 port modelled below has no internal flexibility, the electrical signal is terminated to provide the DS3 signal which is mapped into the ATM VC unterminated. The termination mode of the CTP always takes the value TM_NA (see 3.6.2 (on page 24)).

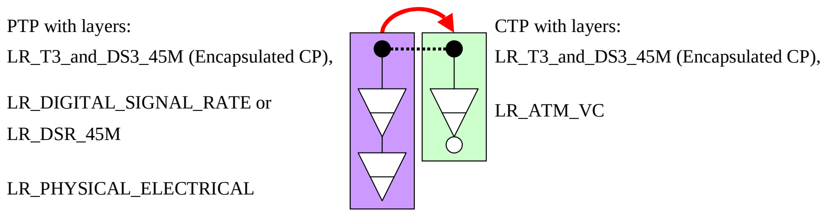


Figure 63 DS3 Circuit Emulation in STM

4.3.4 DS3 trib of a DWDM NE

The DS3 port modelled below has no internal flexibility, the electrical signal is terminated to provide the DS3 signal which is mapped into the Optical Channel unterminated (via the digital signal rate). The termination mode of the CTP always takes the value TM_NA (see 3.6.2 (on page 24)).

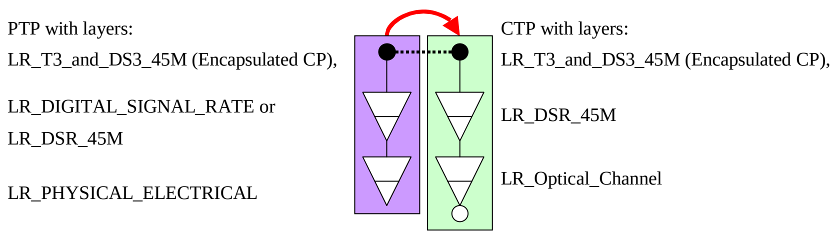


Figure 64 DS3 Trib on DWDM System

4.3.5 Electrical trib (of unknown signal type) of a DWDM NE

The DS3 port modelled below has no internal flexibility, the electrical signal is terminated to provide the free format digital signal which is mapped into the Optical Channel unterminated (via the digital signal rate). The termination mode of the CTP always takes the value TM_NA (see 3.6.2 (on page 24)).

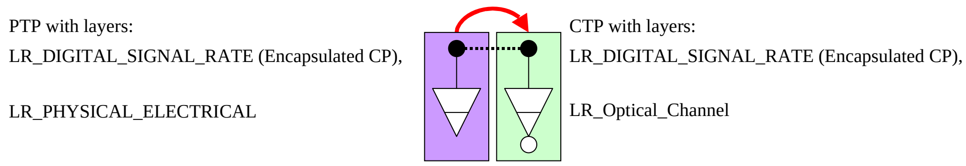


Figure 65 Electrical Trib of Unknown Signal Type to OCH

4.3.6 Electrical Trib

The Electrical port modelled below has no internal flexibility, the electrical signal is terminated to provide the free format digital signal. This is made available for connectivity.

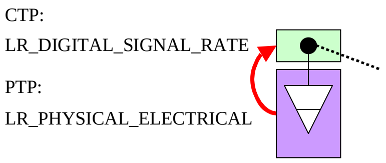


Figure 66 Electrical Trib

4.3.7 Async/PDH Transmux Trib Port

This type of port multiplexes a set of lower order Async/PDH signal (such as DS1/E1) into a higher order Async./ PDH signal (such DS3/E4) and then maps the higher order Async/PDH signal into an SDH/SONET structure (such as VC3/VC4/STS1/STS3c) for crossconnection. The interface currently neither provides proven capability to model nor to name the components of this type of port.

4.4 Optical Port

The reader should study sections 4.1 (on page 49), 4.2 (on page 49) 4.1 and 4.3 (on page 72) prior to reading this section.

4.4.1 Basic DWDM capable Optical port

This port terminates a DWDM signal producing a digital signal of unspecified structure for crossconnection.

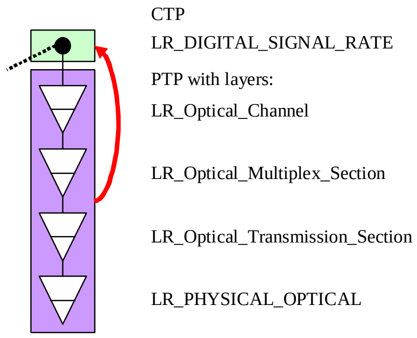


Figure 67 DWDM Capable Optical Port

4.4.2 Basic DWDM capable non-Electrical Optical port

This port terminates two layers of a DWDM signal and produces a single wavelength for crossconnection.

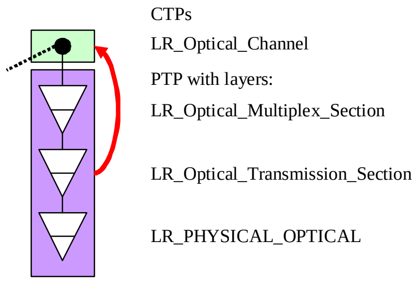


Figure 68 DWDM Capable Non-Electrical Optical Port

4.4.3 DWDM Port with Two Alternative Models

This port offers two different approaches to termination of an optical signal:

- via the full DWDM mapping
- via a basic optical termination

As this PTP two alternative layering presentations, the transmissionParameter THIS_LAYER_ACTIVE is used to indicate which of the two paths through the PTP has been selected (see section 3.3.2 Layering Options on page 18))[9]. The OTS, OMS, OCH and OS layers all offer the parameter. The OTS, OMS and OCH always take the same value which is the inverse of that taken by the OS layer (e.g. when OS is INACTIVE the OCH is set to ACTIVE).

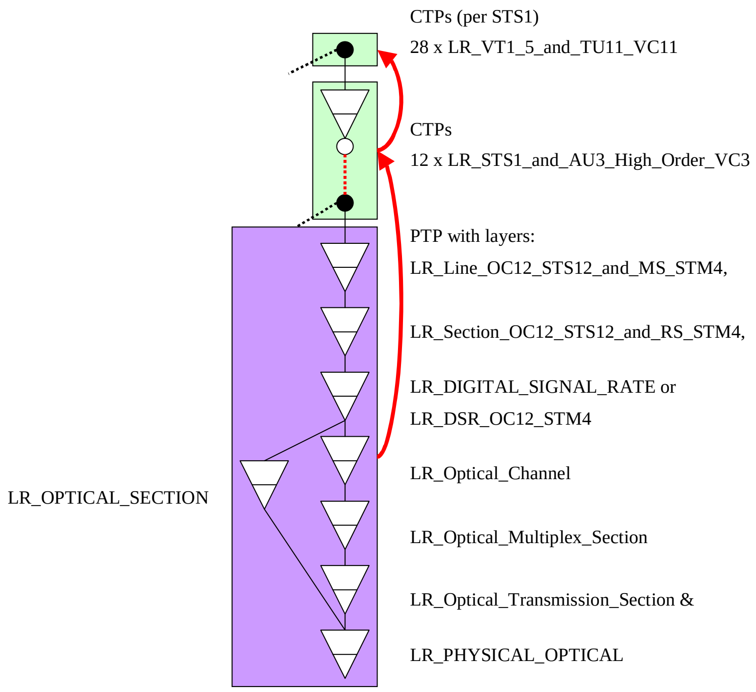


Figure 69 DWDM Port with Two Alternative Models

[9] The mode of operation of the port is controlled by the NE/EMS (via operator provisioning, auto detect, etc).

In MTNM release 3 a further extension to the optical model has been made (see 3.2 Optical Layer Encapsulation on page 15). The following diagram shows a case where the new OTN layer model may be represented/activated in as an alternative to the old models.

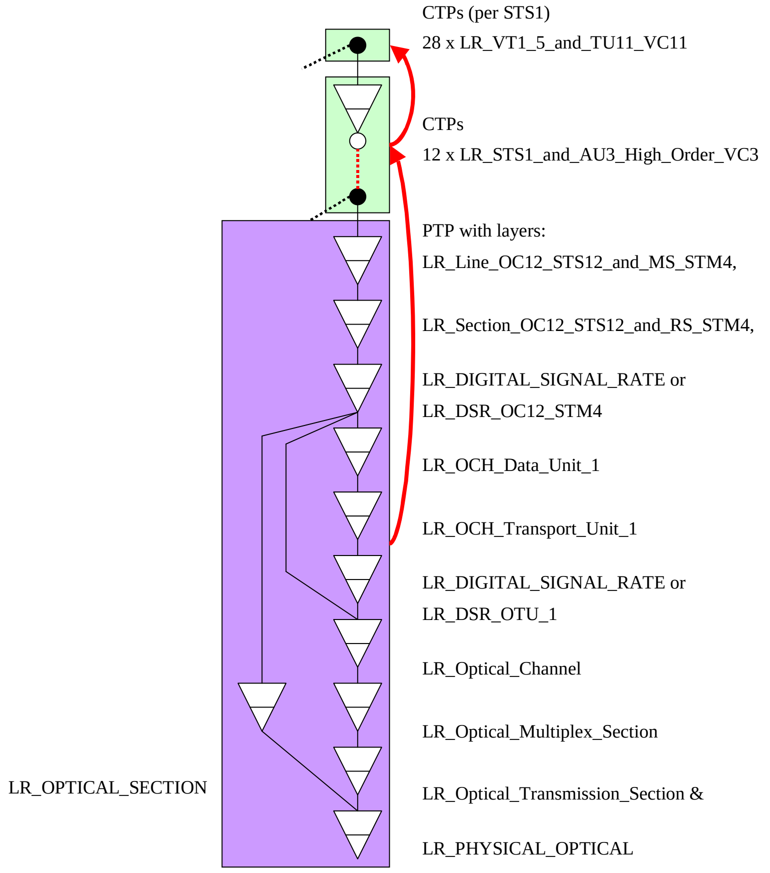


Figure 70 DWDM Port with Three Alternative Models

4.4.4 Basic Optical port that converts to DWDM

This port terminates a basic optical section and produces a single wavelength for crossconnection.

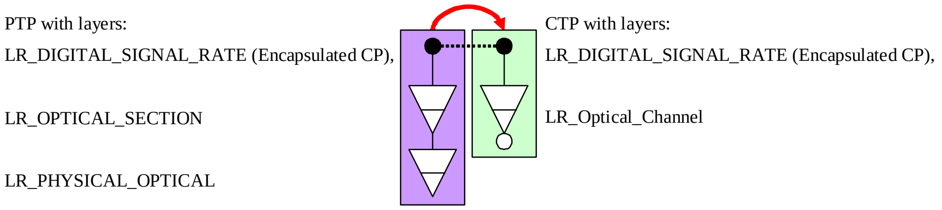


Figure 71 Optical Port That Converts To DWDM

4.4.5 Non-Coloured Optical Amplifier Port

This example shows a port of a non-coloured optical amplifier. This port generates an OS CTP, which is connected to the OS CTP of the other port of the amplifier.

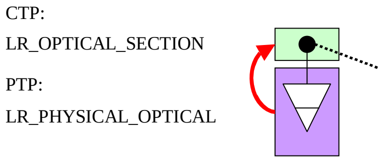


Figure 72 Non-Coloured Optical Amplifier Port

4.4.6 Coloured Optical Amplifier Port

This example shows a port of a coloured optical amplifier. This port generates an OTS CTP, which is connected to the OTS CTP of the other port of the amplifier (this is shown in.

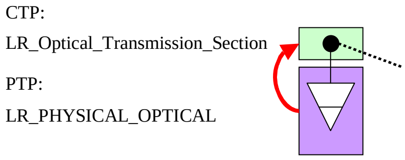


Figure 73 Coloured (WDM) Optical Amplifier Port

4.4.7 Coloured Optical Amplifier

The following diagram shows a basic optical amplifier that amplifies the entire light signal evenly. The ME has no flexibility.

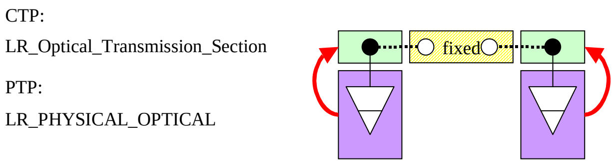


Figure 74 Basic Coloured (WDM) Optical Amplifier

4.4.8 Coloured Optical Amplifier

The following diagram shows a model of an optical amplifier that amplifies the entire light signal but divided into bands. The model uses the concepts of inverse multiplexing to decompose the light signal into a number of banded fragments. These fragments are then amplified separately and then reassembled into the single signal. Attributes are shown that control/monitor the amplification. The ME has no connection flexibility.

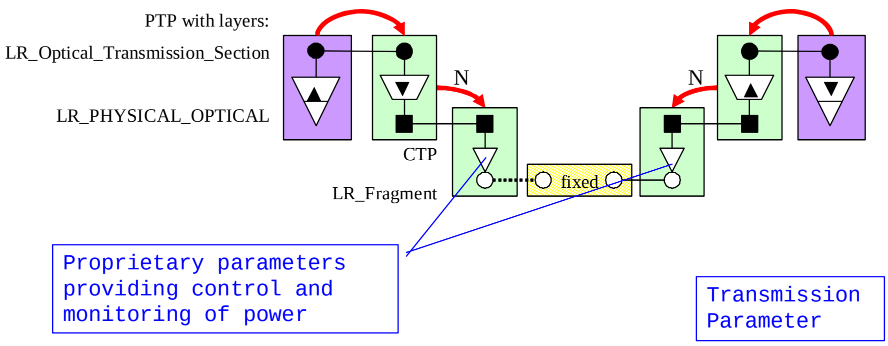


Figure 75 Optical Amplifier with "N" bands of amplification

4.5 ATM ports with Inverse Multiplexing in ports in SDH, SONET, DWDM and ATM NEs

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section.

4.5.1 Inverse Multiplexing of many E1 signals to support ATM

The following diagram shows a number of ports interconnected to support an ATM flow a number of parallel 2M streams.

The ATM signal is constructed in the normal fashion VCs mapped into VPs into ATM-NI. The ATM-NI is encapsulated in an FTP that supports Inverse Multiplexing. The contained N server CTPs of the FTP map 2M signals into fragments signals for assembly by the ATM-NI TP.

These N contained CTPs connect to supporting CTPs of the PTPs that provide E1 physical ports (or directly to the PTPs using the SNC enhancements specified in section 8 SNC versus TL, Trail and Network Connection Modelling on page 106).

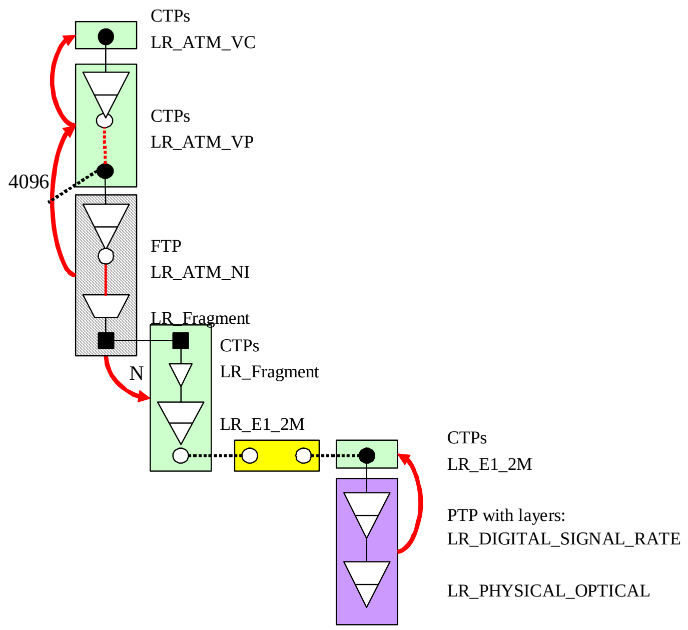


Figure 76 Inverse multiplexing of an ATM VP signal over multiple E1s

4.6 Unspecified signals with Inverse Multiplexing in ports in SDH, SONET and DWDM NEs

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section.

4.6.1 Inverse multiplexing of a high rate unspecified digital signal over a number of VC4s

The following diagram shows a number of ports interconnected to a flow of a high rate unspecified digital signal over a number of parallel VC4 servers that themselves are multiplexed into a single Multiplex Section that is itself crossconnected to other ports in the ME (shown in Figure 78 ME view of Inverse multiplexing of an undefined digital signal over multiple VC4s on page 82).

Several of the ports show non-intrusive test capability. The PTP contains a number of reverse layer CTPs supporting inverse multiplexing.

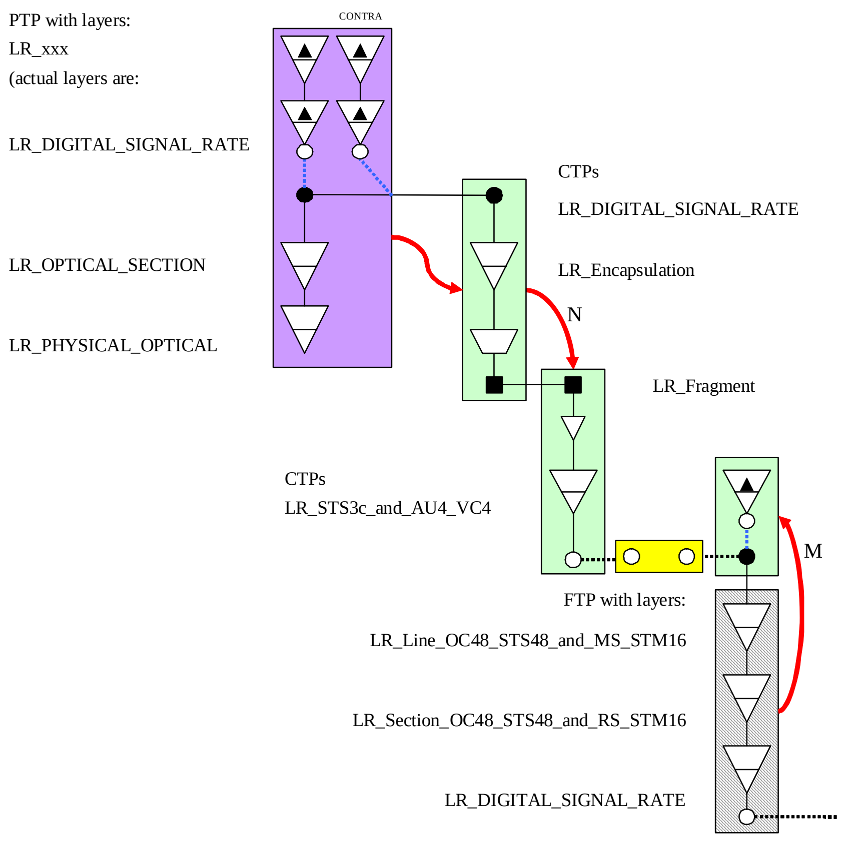


Figure 77 Inverse multiplexing of an undefined digital signal over multiple VC4s

The following diagram shows a fragment of a ME including the port described above.

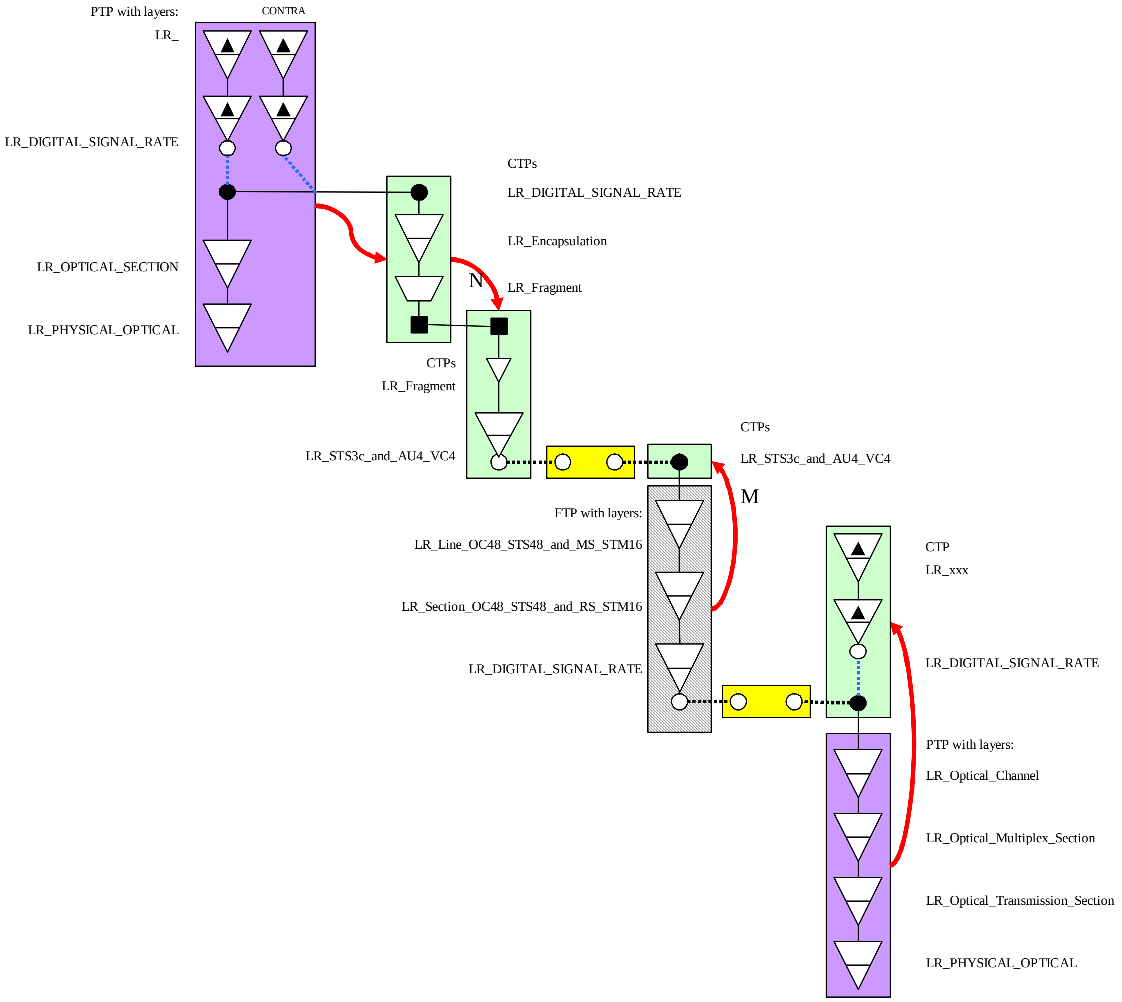


Figure 78 ME view of Inverse multiplexing of an undefined digital signal over multiple VC4s

4.7 DSL ports utilizing the Remote Unit capability

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section.

4.7.1 Basic DSL port modelling

The following diagram shows two models for DSL port (see also SD1-7_DSLOverview.pdf) and equipment modelling. The second (lower) model takes advantage of the Remote Unit capability (described in section 3.10 Remote Unit Encapsulations on page 37) to reduce the number of PTPs, MEs and topological links. The PTP in the second (lower) model has a single list of layers and the Remote Unit capabilities are identified using the string prefix "RU" on transmission parameters and probable causes etc.

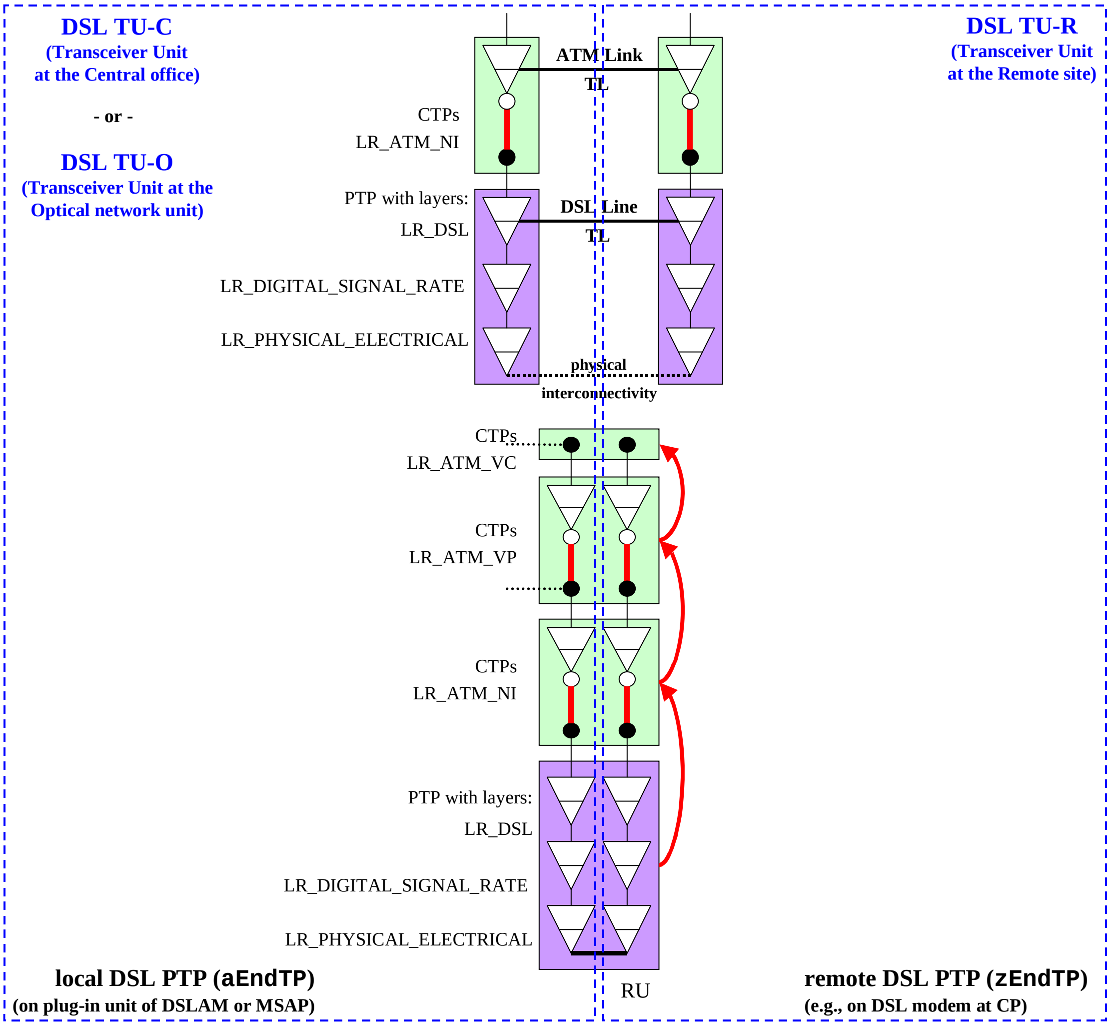


Figure 79 Two models of DSL ports carrying ATM

4.8 Ethernet port modelling

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section.

4.8.1 Inverse Multiplexing of many VC4/STS3c signals to support Ethernet

The following diagram shows a number of ports interconnected to support an Ethernet flow a number of parallel VC4/STS3c streams. The VC4s/STS3cs may be routed over the same SDH/SONET port or over different SDH/SONET ports in the NE depending upon the Inverse Multiplexing implementation.

The Ethernet signal is decomposed into fragments that are then mapped into VC4s/STS3cs and crossconnected to one or more SDH/SONET ports.

Note that the layer that links the containing LR_Ethernet PTP and contained LR_Ethernet CTP is repeated in both TPs. This TP repetition indicates that a contained TP is not the client of its containing TP.

Some NEs have the capability to configure dynamically the fragmented layer rate, i.e. – the EMS modifies the configuration of the CTP C (shown in Figure 80 Gigabit Ethernet Port in an SONET/SDH NE (Fragmentation with STS3c/VC4) on page 85) by replacing the layer rate LR_STS3c_and_AU4_VC4 by LR_STS1_AU3_High_Order_VC3. A transmission parameter "Fragment_Server_Layer", is used to indicate which server layer is being used. The value of this parameter is an integer. The AVC notification on this transmission parameter will allow a NMS to be aware that a layer rate change has occurred in the EMS.

The LR_Encapsulation layer is used when a network element can be configured to provide encapsulation of the client Ethernet layer. As there are many types of possible encapsulation methods, the active method will be indicated by the transmission parameter "*ProtocolIdentifier"* that can take the following values: "*HDLC_PPP*", "*ML_PPP_BAP*", "*HDLC_LAPS*", "*GFP_TRANSPARENT", "GFP_FRAME_MAPPED"*.

The naming scheme of the LR_Fragment CTP will append an index number starting with "1" and this number is independent of the "Sent Sequence Number", "Accepted Sequence Number" or "Expected Sequence Number". The reason for this is that those values are made available to a management system after the connection is activated. Therefore, the sequence number is not available at the time of creation of the LR_Fragment CTP by the EMS. As CTP C incorporates components of several layers (LR_Fragment and LR_STS3c_and AU4_VC4), the naming of this CTP uses the layer rate of the connectable component of the diagram, which is LR_STS3c_and_AU4_VC4.

The Fragment layer in CTP B (shown in Figure 80 Gigabit Ethernet Port in an SONET/SDH NE (Fragmentation with STS3c/VC4) on page 85) is used to define inverse multiplexing in a generic way (IMA and SONET/SDH Virtual Concatenation). In order to avoid very specific behaviour of Fragment layer related to Virtual Concatenation, a transmission parameter for the Fragment layer rate: "Dynamic_Fragmentation" has been provided. The purpose of this transmission parameter is to allow the NMS to retrieve the Fragment capability related to the bandwidth management support. It can take the following values: "LCAS", "IMA".

When Dynamic_Fragmentation = "LCAS", NMS is allowed to hitlessly increase or decrease the capacity of a virtual concatenated link by adding or removing server Fragment CTP crossconnects in order to meet the bandwidth needs of the application.

When Dynamic_Fragmentation = "IMA", it indicates that dynamic fragmentation for ATM Inverse Muxing is used.. Behaviour is similar to the above (but it applies to the IMA group and its components).
The absence of this transmission parameter indicates that dynamic bandwidth management is not supported (e.g., LCAS and IMA is not supported).

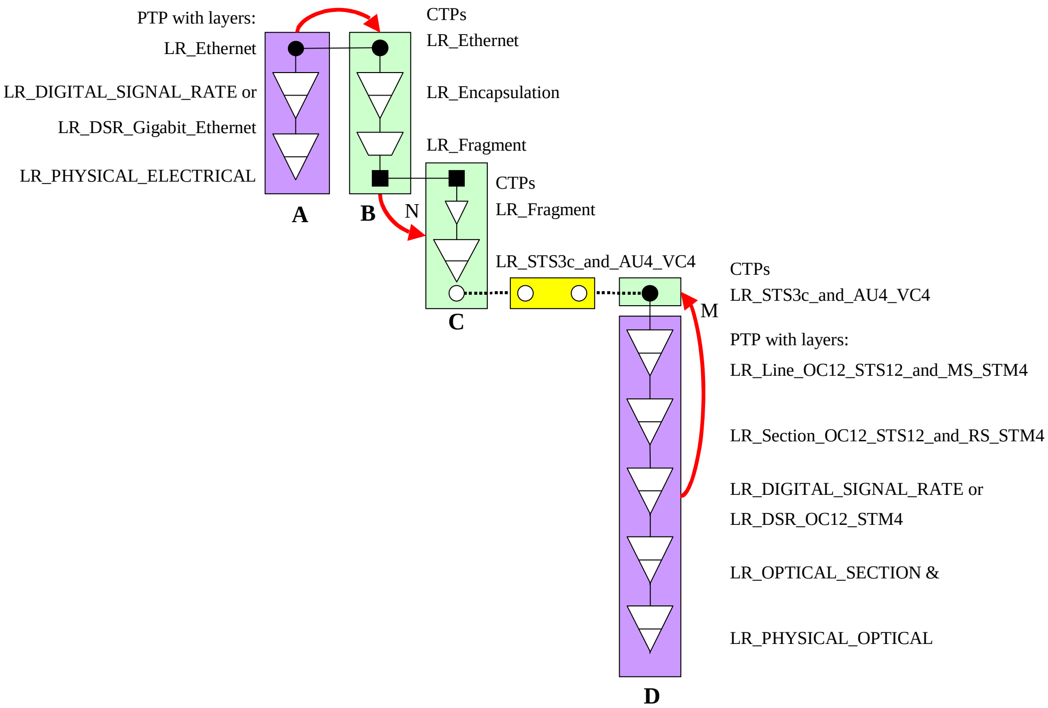


Figure 80 Gigabit Ethernet Port in an SONET/SDH NE (Fragmentation with STS3c/VC4)

4.8.2 Inverse Multiplexing of many VC3/STS1 signals to support Ethernet

The following diagram depicts the layering of a Gigabit Ethernet tributary port, which signal is fragmented and carried over one or more STS1/VC3 signal. In this case, up to 24 x STS1/VC3 are needed to carry the 1 Gigabit Ethernet when the whole capacity is in use and the STS1/VC3 time-slots are not required to be contiguous.

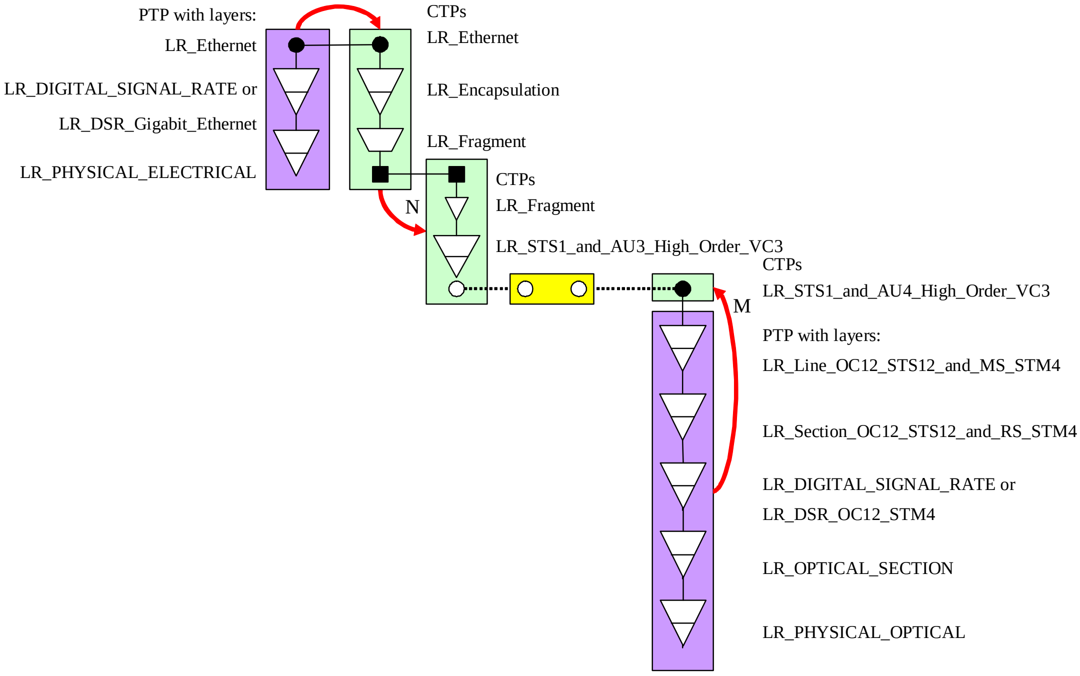


Figure 81 Gigabit Ethernet port in a SONET NE (Fragmentation with STS1/VC3)

4.8.3 Inverse Multiplexing of many VC3/STS1 or VC4/STS3c signals to support Ethernet

The following diagram depicts the layering of a Gigabit Ethernet tributary port, which signal is fragmented and carried over one or more STS1/VC3 signal or over one or more STS3c/VC4 signals.

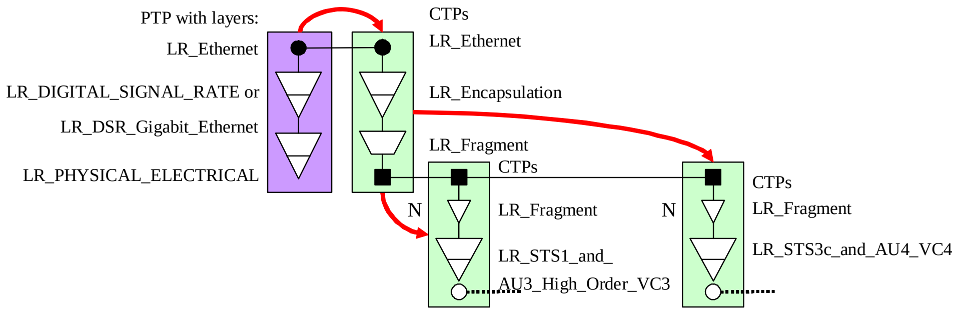


Figure 82 Gigabit Ethernet port in a SONET NE (Fragmentation with STS1/VC3)

4.8.4 Alarms and Attributes for an Inverse Multiplexed Ethernet signal

The following diagram shows alarms and attributes for an Inverse Multiplexed Ethernet example.

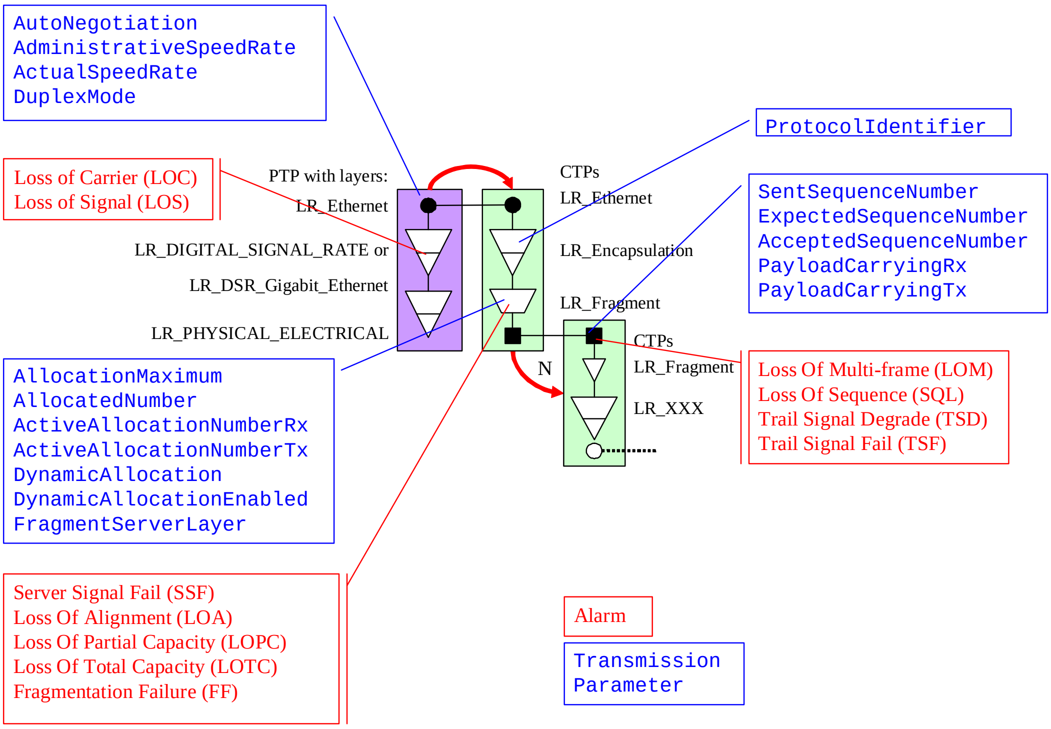


Figure 83 Ethernet/Fragmentation layering with transmission parameters and alarms.

4.8.5 Inverse Multiplexing of many VT1.5 signals to support Ethernet

The following diagram depicts the layering diagram of an OC3 port that is capable of terminating STS1 and can provide VT1.5, which after Fragmentation adaptation provides Fast Ethernet signal. Up to 56 x VT1.5/VC11 is needed to carry the Fast Ethernet signal. The ATM IMA can also be modelled using the LR_Fragment layer. It also requires the use of Floating TP.

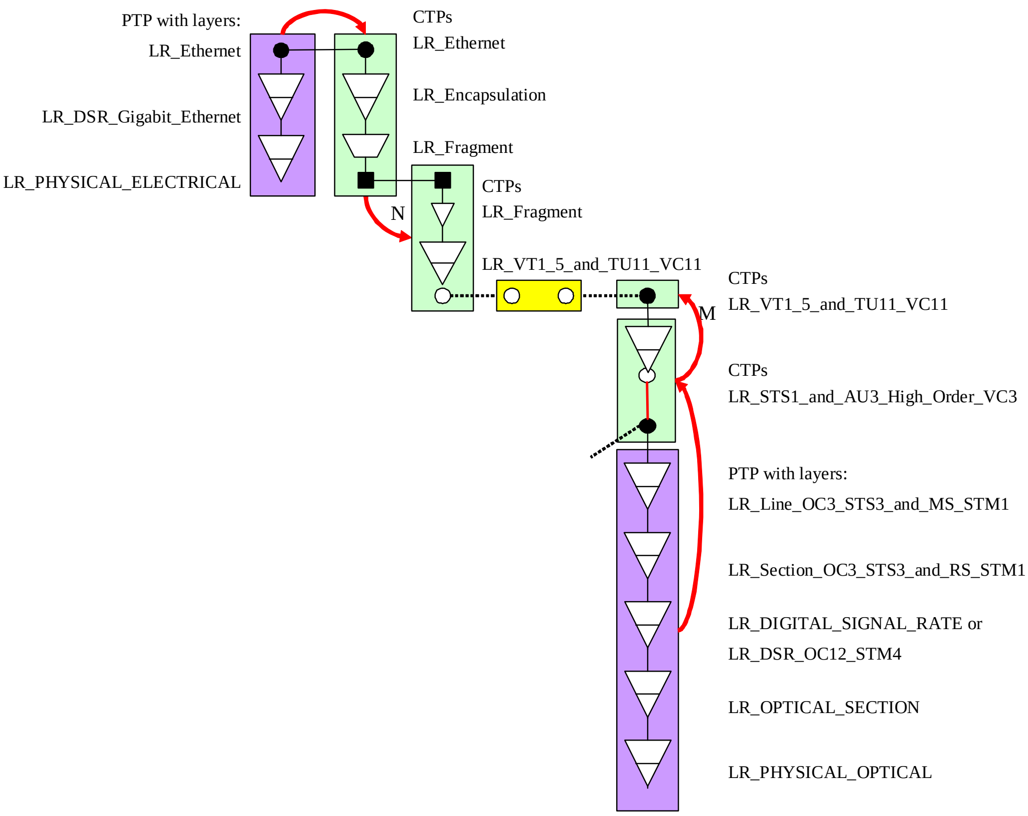


Figure 84 Fast Ethernet port in a SONET NE (Fragmentation with VT1.5/VC11)

4.8.6 Direct Multiplexing of Ethernet over VC4-4c/STS-12c carried by STM-16/OC48

The following diagram shows a direct mapping of Ethernet over a VC4-4c/STS12c which is itself carried by STM-16/OC48.

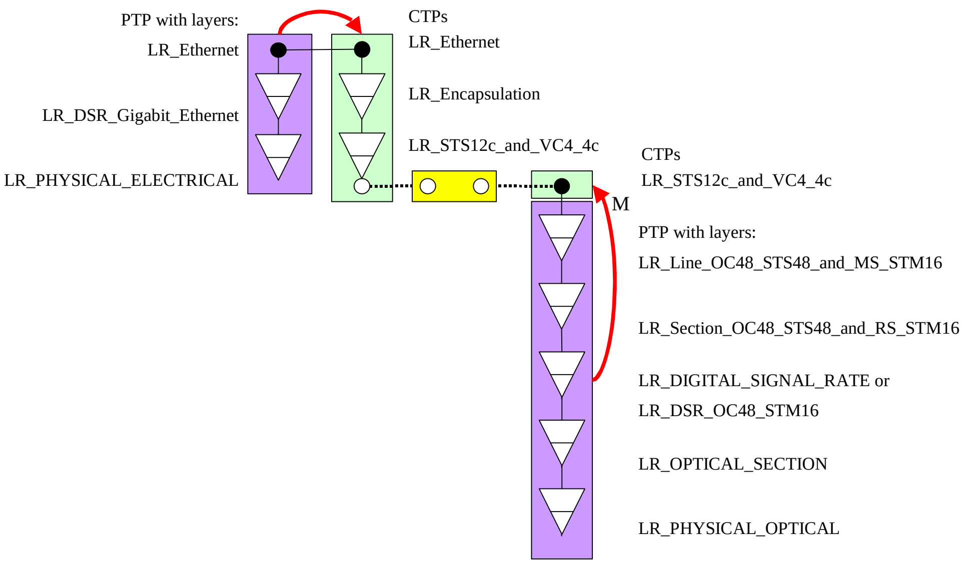


Figure 85 Gigabit Ethernet port in a SONET NE without Fragmentation

4.9 Wireless port modelling

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section.

4.9.1 STM-1 Wireless ports

Basic STM-1 wireless systems potentially allow two STM 1 signals to be transferred over a single radio signal. This has been accommodated by introducing a 2xSTM-1 layerRate.

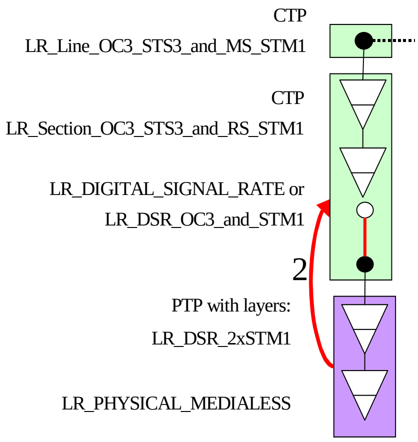


Figure 86 Wireless port capable of carrying 2 x STM1

This PTP may be used in a simple ME with fixed connectivity to transfer two STM-1 signals (see also section 5 Fixed Crossconnect Usage on page 94)

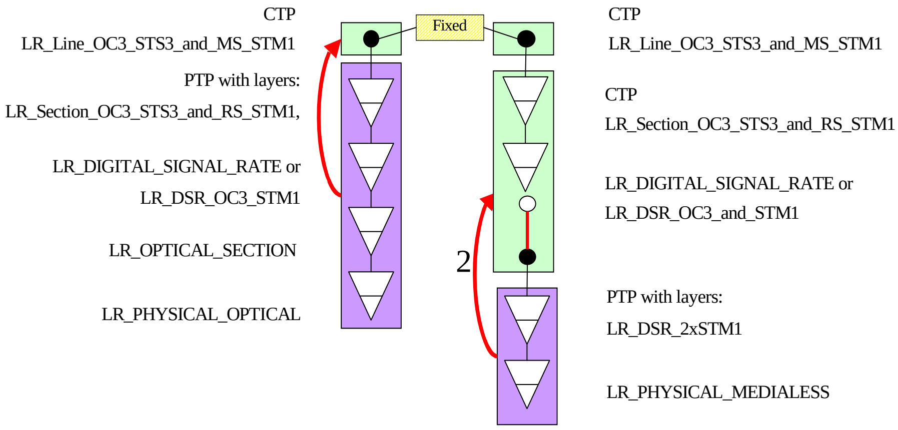


Figure 87 Wireless ME capable of carrying 2 x STM1

4.9.2 Wireless Protection

A wireless protection scheme may be used to enhance the resilience of the system. This scheme uses the same modelling as SDH/SONET Multiplexer Section Protection. The figure below shows the ports involved. Refer to SD1-34_protectionSwitch.pdf for further information on protection schemes.

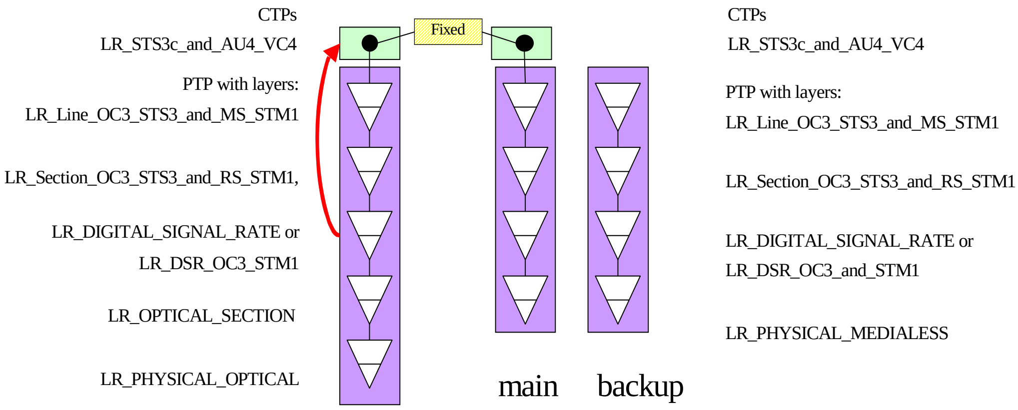


Figure 88 Wireless Protection

4.10 Non-intrusive monitoring and Tandem Connection Monitoring

The reader should study sections 4.1 (on page 49) and 4.2 (on page 49) prior to reading this section. Examples will be added in a future release of this document.

5 FIXED CROSSCONNECT USAGE

The following sections provide a very brief overview of fixed crossconnects.

For a vast majority MEs each case in the ME where the cross connection between two TPs can not be adjusted in any way give rise to simple hidden relationships between layers within a TP (PTP, CTP, FTP) or between TPs as containment. However in some cases it is not possible to "hide" the relationship as either the cardinality of the relationship is not simple or the fixed nature of the relationship is "temporary" and caused by some other configuration of the ME.

For example, some MEs support TPs that can work in 2 modes depending upon the configuration of the ME:

- fixed multiplexing and cross connecting
- flexible cross connect

Taking an example an ME that supports only a single layer of connection flexibility per signal passing so flexible crossconnection may be performed at VC12 or at VC4 but not both for any particular signal (due to an intentional design limitation in the fabric of the ME). Consider a 2Mb card which supports physical 2Mb ports that can be either flexibly cross-connected at VC12 level to STM-n ports where the VC4 is mapped directly into the port. Alternatively all the VC12s may be connected in a fixed relationship on the card into a VC4 FTP and this FTP may then be flexibly cross-connected at VC4 level.

The VC4 TP can be configured in 3 modes as shown in the following figures:

- In mode "fixed cross connect" as shown in Figure 89 Client Crossconnect/SNC is fixed on page 95, the low order TP are connected in the fixed manner into a high order FTP.
- In mode "flexible cross connect" as shown inFigure 90 Client Crossconnect/SNC flexible on page 95, the low order CTPs can be flexible cross connected to other low order CTPs on some others.
- In mode "not set" as shown inFigure 91 Client Crossconnect/SNC is not present on page 95, the containing TP is not configured in either modes above. It means it can be configured in any of the above mode at a later time.

This is modeled through the interface by reporting fixed VC12 cross connect between CTPs derived from the 2 Mb physical ports on one hand and from CTP derived from the FTP on the other hand.

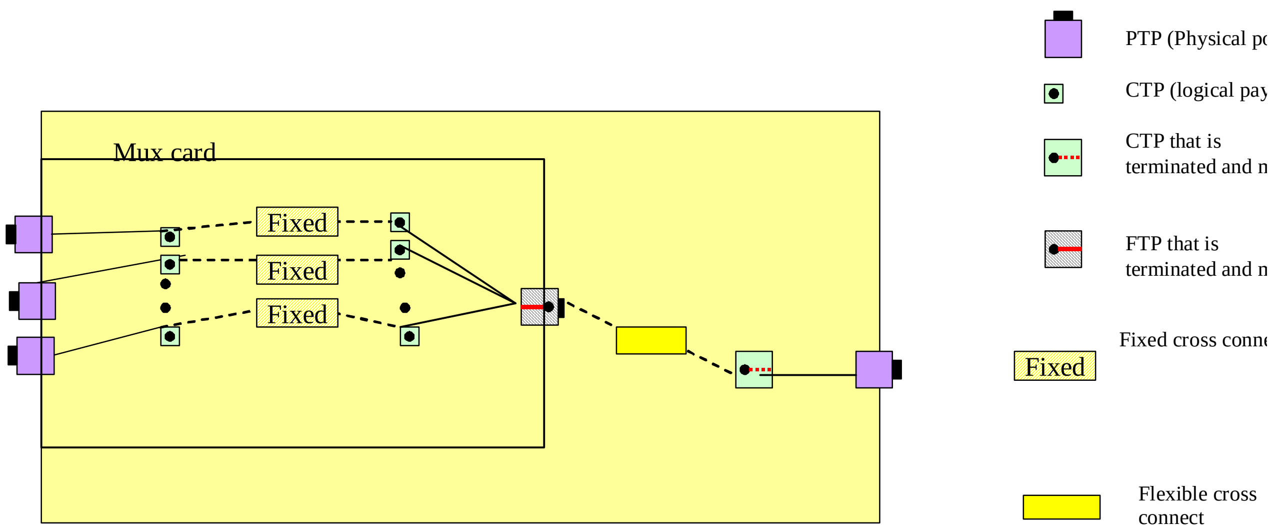


Figure 89 Client Crossconnect/SNC is fixed

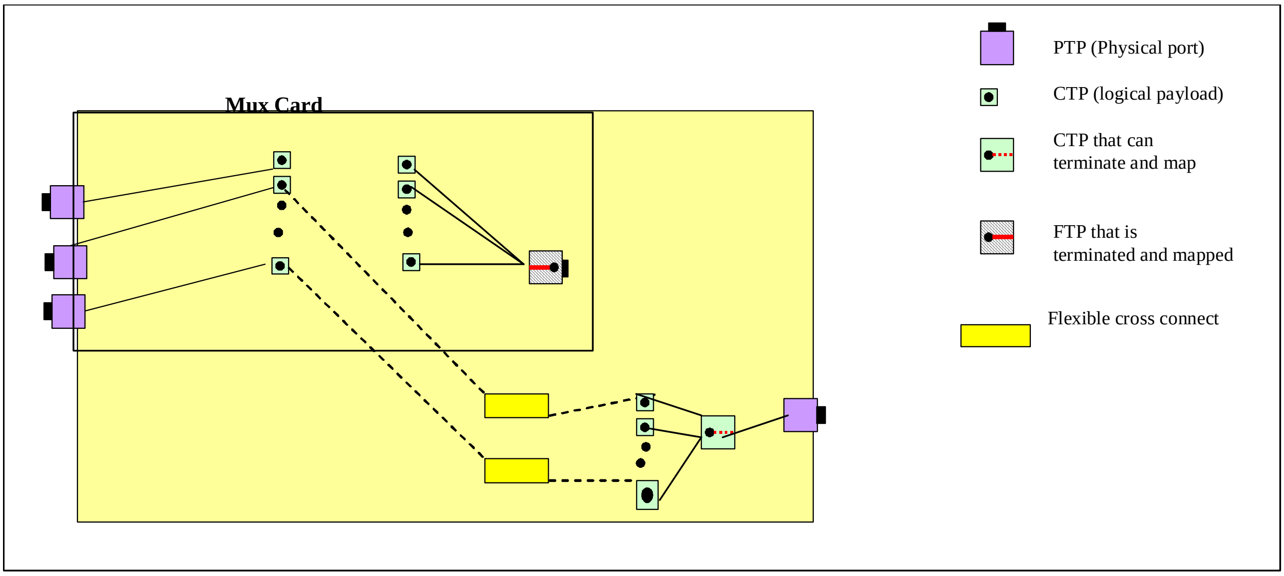


Figure 90 Client Crossconnect/SNC flexible

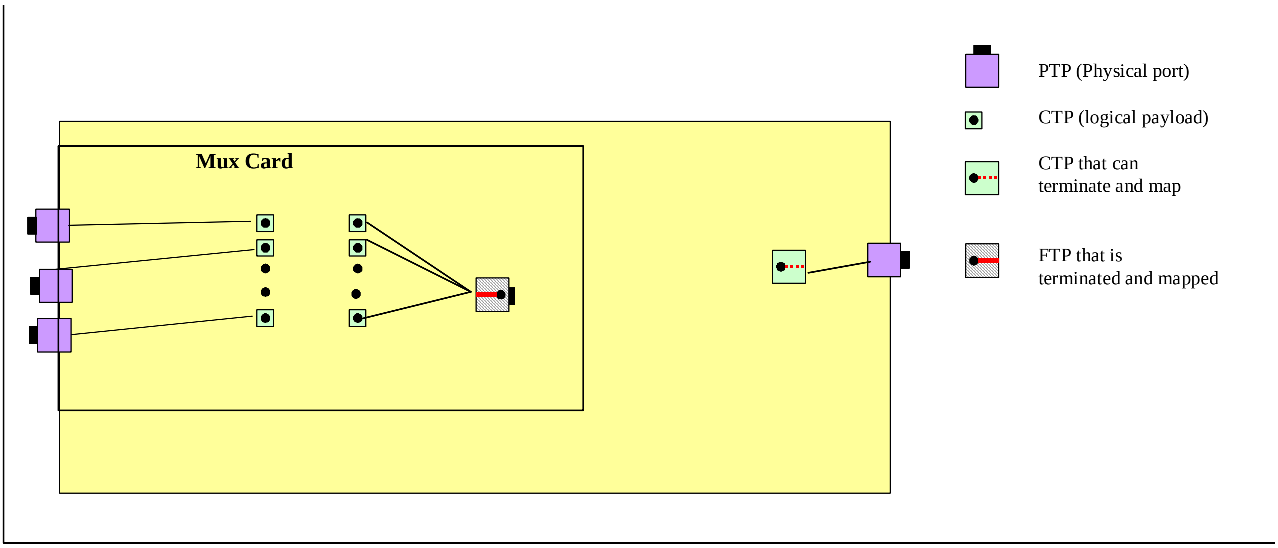


Figure 91 Client Crossconnect/SNC is not present

6 TOPOLOGICAL LINKS

Prior to release 3 a Topological Link (TL) was either a physical link between two PTPs, at the lowest (server-most, closest to physical) common layer (highest common layer rate) of which the EMS has accurate knowledge, or an ATM link between two ATM NI CTPs. In release 3 of the MTNM model, the ATM link case is extended to trails between two arbitrary termination points which have the layer rate of the topological link in common and encapsulate a TTP at this layer. This chapter considers examples of physical links and ATM links. Refer to chapter 8 for examples of release 3 topological links.

6.1 Layering of Topological Links and Principles

The topological link of the MTNM model allows an EML to report interconnectivity between PTPs of NEs within subnetworks and at the edges of subnetworks. The topological link represents interconnectivity at a single layer rate between a G.805 TTP encapsulated by the PTP at one end and the PTP at the other. It does not necessarily represent the physical interconnectivity between the NEs.

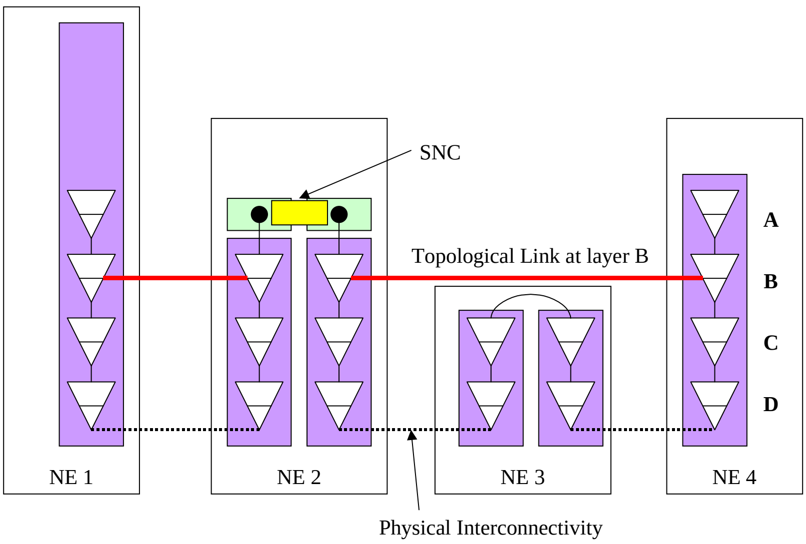


Figure 92 Link Layering

For example, in Figure 92 (on page 96), the EML exposes a layer B topological link to the NML between a port of NE1 and a port of NE2 which in this case happens to reflect the physical interconnectivity since it is assumed that the EML does not know layers C and D accurately enough for NE1. The EML also exposes a layer B topological link to the NML between a port of NE2 and a port of NE4 that clearly does not reflect the physical interconnectivity. In the latter case, the positioning of NE 3 is not indicated to the NML and from the NML perspective NE3 is floating.[10] For example, NE 3 may be an SDH/SONET regen in a network where the connectivity can only be verified at the Multiplex Section/Line layer.

The EML should report Topological Links at the lowest layer (i.e., closest to physical or server-most) about which it has accurate knowledge. With the Topological Links alone the NML will not have sufficient information to determine the flow of traffic through an NE, the Topological Link information must be used in conjunction with SNCs in the appropriate layer. This applies not only to layers in which an NE is flexible, but also when an NE supports an inflexible SNC between CTPs of two PTPs (as shown in the figure within NE 2). To provide sufficient information about traffic flow the EML should report an SNC (crossconnect) to

[10] The EML should only report topological link connectivity of which it has accurate knowledge. It would be wrong in the case shown for the EMS to report a layer C topological link between NE2 and NE4.

represent the traffic flow through NE 2 in layer A even if the SNC can not be deleted.[11] An example of this would be an SDH/SONET regenerator which provides fixed MS/Line layer SNCs between its PTPs. Although in some cases, for example when the regenerator has only two PTPs equipped, it would be possible for an NML to infer the connectivity within the NE, in general this is not the case. To maximize consistency the EML should report all flexible and inflexible SNCs.[12]

6.2 Topological Links in SDH, ATM and OTN/DWDM

The following section details the topological link model to be reported for various different EML consolidations. It specifies the topological link responses expected for the cases of a single EMS for the whole network and of separate EMSs for WDM, ATM and SDH. A number of alternative presentations are highlighted for some cases.

6.2.1 Network Considered for the Topological Link Examples

The following diagram shows a number of sites (coloured rectangles A-H) containing a variety of network elements (1-22). The topology diagrams in the following sections highlight threads through this network.

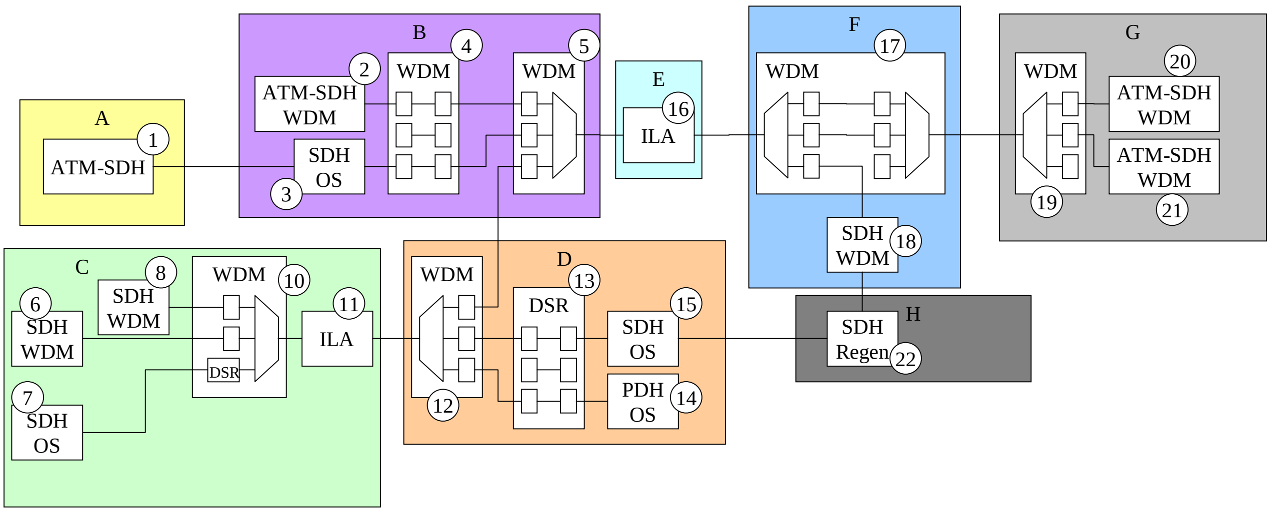


Figure 93 Network Diagram for Topology Discussion

6.2.2 Basic Regen Cases

The following diagrams show two different presentations of the interconnectivity between SDH components (NE15, NE22 and NE18). It should be noted that NE18 is assumed to either be providing a simple SDH port or to be providing a dual modelled port with the OS Layer set to ACTIVE (see section 3.3.2 on page 18).

[11] From release 3 onwards such an SNC can be marked as being fixed (see chapter 5 on page 94).

[12] A signal can only flow across an NE from CTP to CTP via an SNC.

The first diagram shows the view presented by an EML that manages both the multiplexers (NE15 and NE18) and the regenerator (NE22). The EML has chosen to report the position of the regen NE22 and shows RS Topological Links between NE15 and NE22 as well as between NE18 and NE22. The internal connectivity in the regenerator (NE22) is represented by an SNC (= crossconnect), reported over the interface to the NML by the EML.

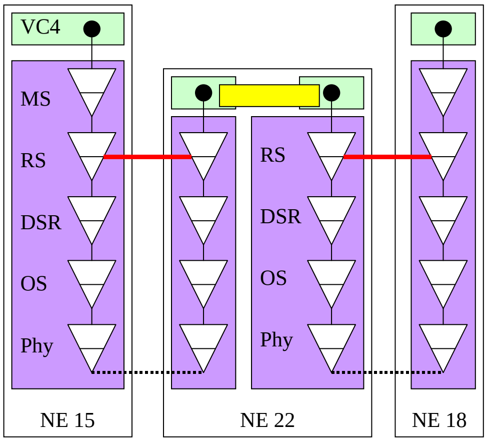


Figure 94 SDH Regen topology reported

The next diagram shows the case of an EML that has chosen not to expose to the NML the interconnectivities between the SDH multiplexers (NE15 and NE18) and the SDH regen (NE22), although the EML does report the regen (NE22) to the NML. The NML will need to build the regen into the network model for other information (using NML-provisioned TLs between NE15/NE18 and NE 22), the EML presentation is that of a floating NE22. The topology view is the same that would be achieved if the EML device managing NE15 and NE18 was not the device managing NE22. Again the EML responsible for the regenerator (NE22) reports the internal connectivity of the regenerator to the NML via an SNC (= crossconnect). From release 3 onwards on the MS layer an SNC could be provisioned instead of a TL (see the lower SNC in section 8.2.9)

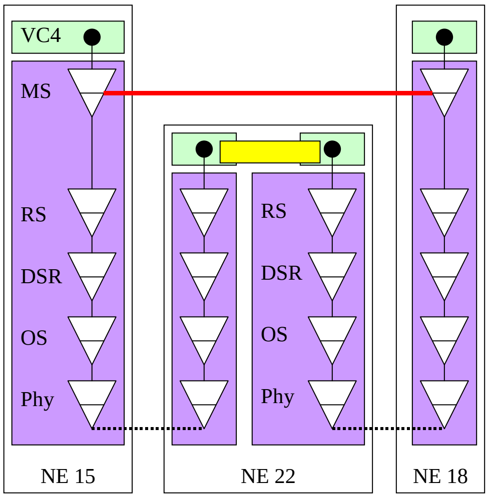


Figure 95 SDH Regen topology not reported

6.2.3 SDH and WDM Combination

Consider the VC4 traffic flow from NE6[13] to NE14, as shown below. Assuming that the EML device manages all the network elements then the most appropriate topology picture is that shown below. Note again that all devices represent the interconnectivity between ports via an SNC (crossconnect).

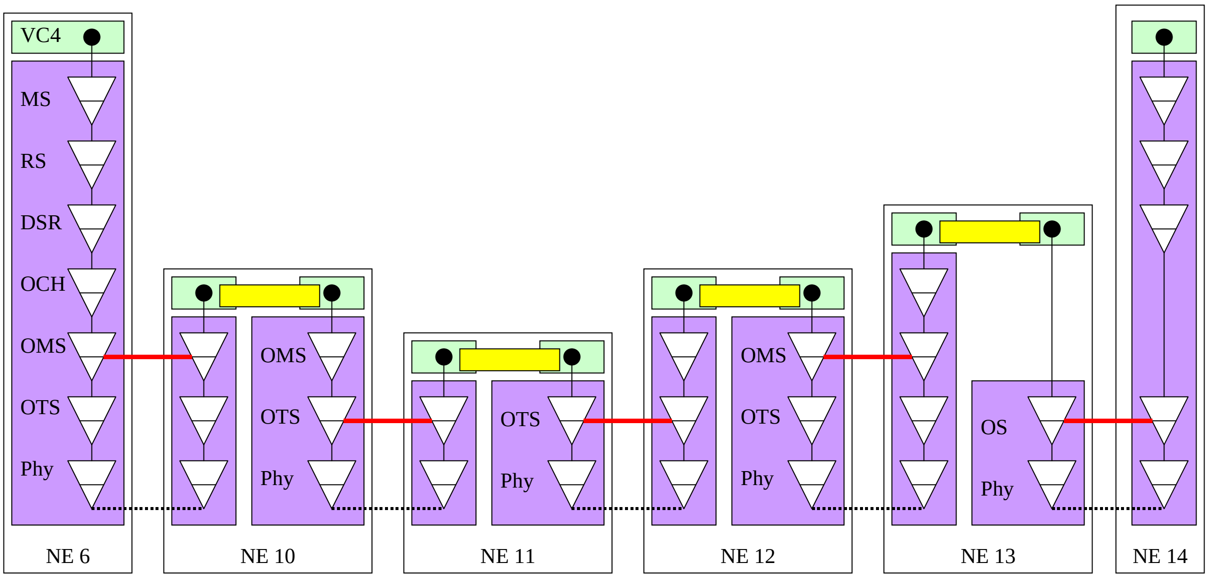


Figure 96 Basic Link Arrangement for DWDM

Now consider the case where the SDH NEs (NE6 and NE14) are managed by one EML device (EML1) and the DWDM NEs are managed by another EML device (EML2). In this situation the NML can only gain partial information from the EML devices.

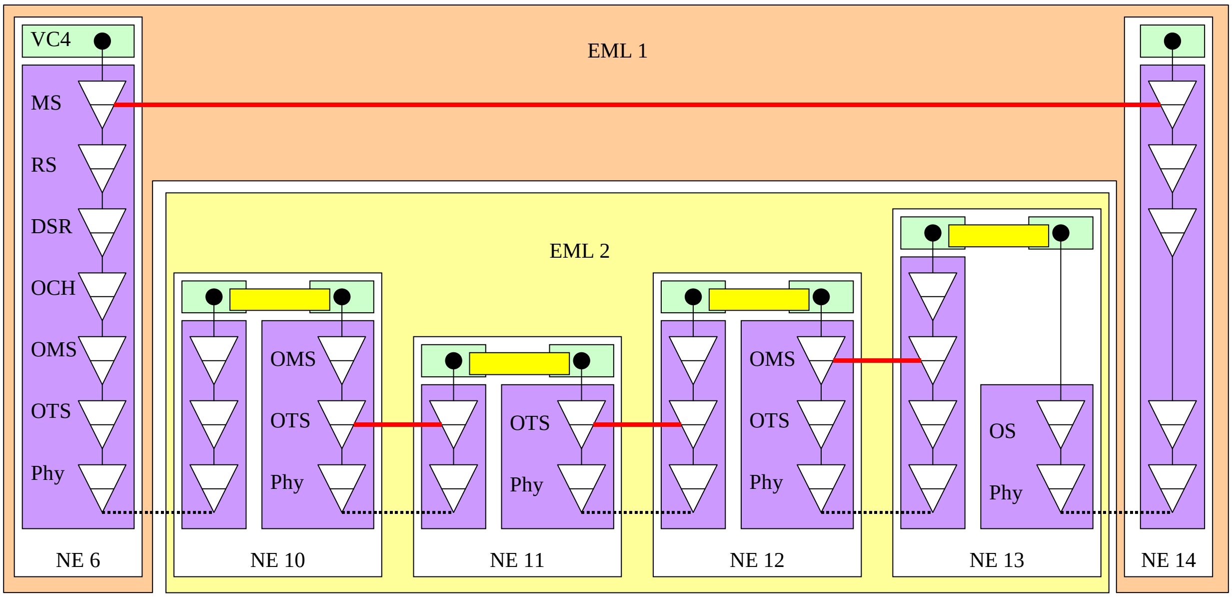


Figure 97 Basic Link Arrangement for DWDM

[13] NE 6 is unaware of the OTS layer interconnectivity.

6.2.4 ATM, SDH and WDM Combination

The diagram below shows a symmetric combination of ATM, SDH and WDM NEs being interconnected by NE16 which is an in-line amplifier (ILA). In this case a single EML device is assumed to be managing the entire network. The EML device has opted to report Topological Links for the DWDM layers but has also chosen to report the ATM NI topological link. In this case the EML is presenting the network as two subnetworks (see section 7.1 on page 103 for an equivalent example showing the subnetworks). The ATM link is used in the ATM subnetwork and the other links are used in the WDM/SDH subnetwork.

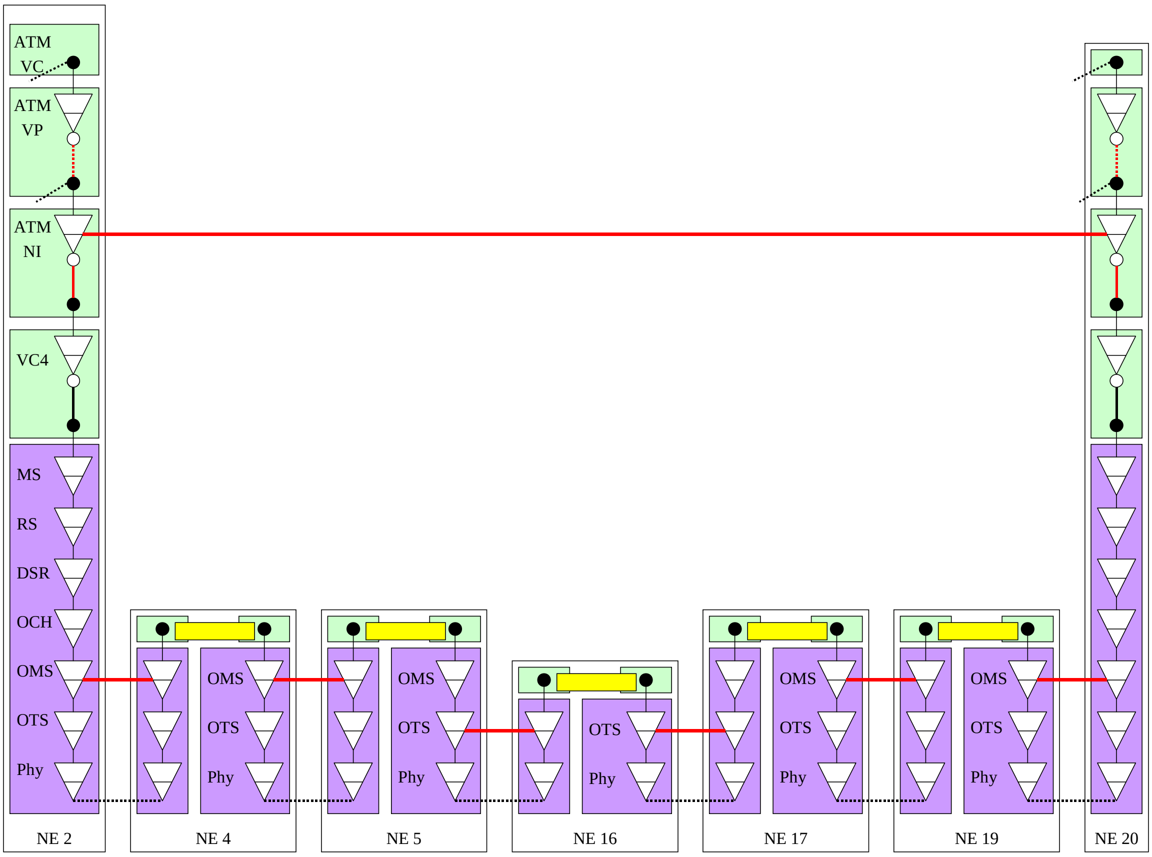


Figure 98 ATM and DWDM managed by single EML device

It is likely that two separate EML devices are managing the network, one dealing with the ATM NEs (NE2 and NE20) and the other with the DWDM NEs (NE4, NE5, NE16, NE17 and NE19). The ATM EML device (EML1) will report the ATM NI topological link and the DWDM EML device (EML2) will report the other Topological Links thereby baring the physical interconnectivities NE2-NE4 and NE19-NE20, both of which cross the EML boundary. These outer interconnectivities can be reported as off network topological links (see section 7.3 on page 104).

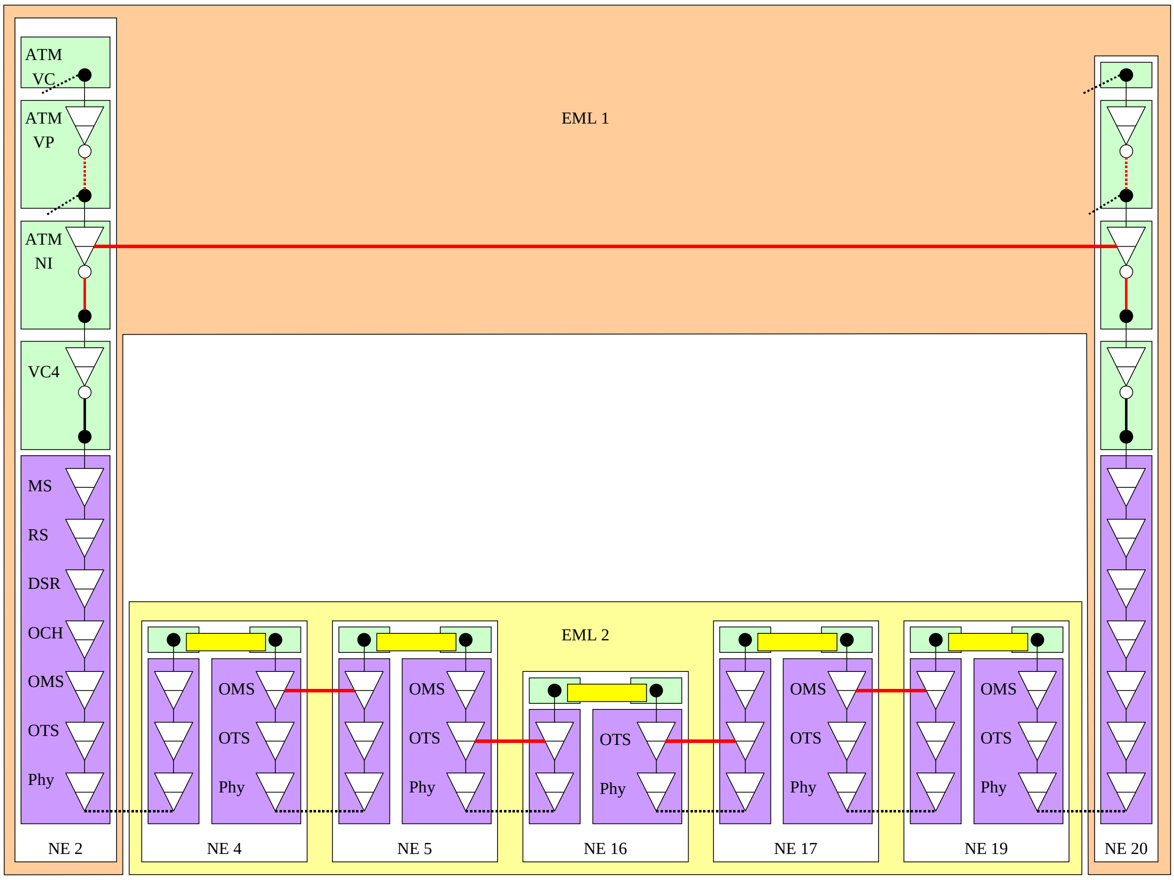


Figure 99 ATM and DWDM managed by two EML devices

6.2.5 OTN Example

The following example shows a basic optical signal from NE 7 introduced to a WDM network and passing across that network to an SDH ME that supports WDM optics.

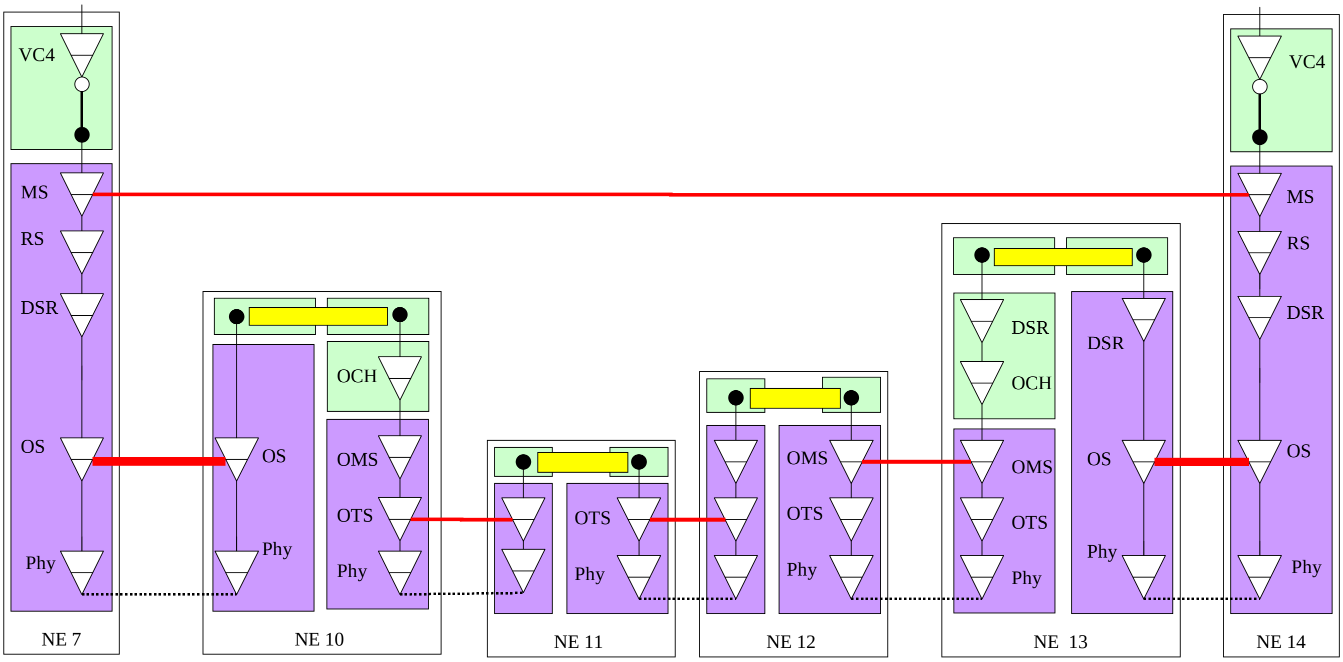


Figure 100 Optical transmission system

7 SUBNETWORK LAYERING AND TOPOLOGICAL LINKS

This section details the use of topological links within the interface and the network considered is that identified in Figure 93 Network Diagram for Topology Discussion (on page 97). There are many ways that the responsibility for management of the NEs can be partitioned between EMSs, for example all of the NEs could be managed by the same EMS or alternatively all the ATM NEs could be managed by one EMS and all SDH NEs be managed by an SDH EMS while a WDM EMS manages the WDM NEs.

The examples (Figure 101 on page 103 to Figure 105 Single EMS with interconnected subnetworks on page 105) assume that the NEs 1, 3, 4, 5, 16, 17, 19 and 21 shown in Figure 93 on page 97 are the only managed NEs in the network and that all physical connections other than those directly between the NEs listed are actually made.

The diagrams show NEs related to a subnetwork within the subnetwork ellipse and repeat an NE where it appears in several subnetworks (an NE that is repeated on the diagram will, over the interface, list the subnetworks that it belong to). Links (shown in red) are top level if they cross the boundary of the subnetwork ellipse.

7.1 Topological links where the EML is presenting multiple subnetworks

The following example covers the case of a single EMS that is managing all the NEs and is offering separate subnetworks per technology. The EMS provides no top level topological links.

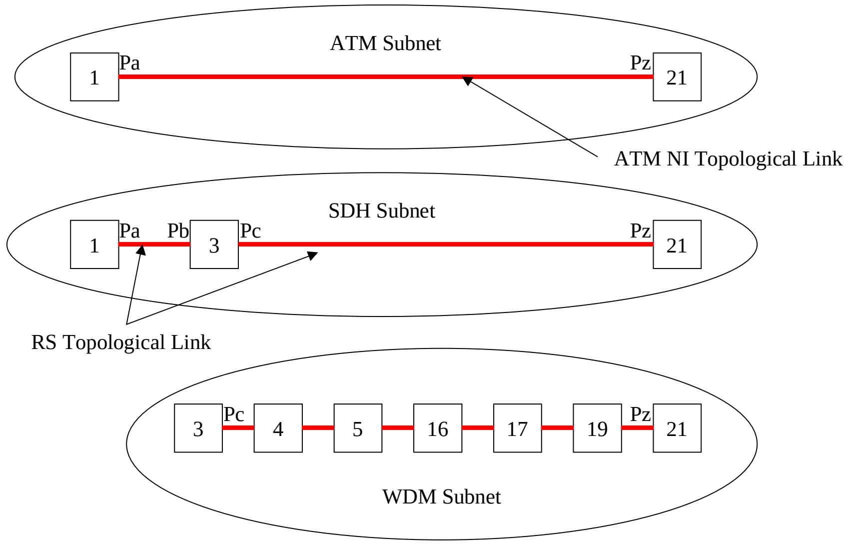


Figure 101 Single EMS showing technology subnetworks

7.2 Topological links where the EML is presenting a single multi-layer subnetwork

The following example covers the case of a single EMS that is managing all the NEs and is offering one subnetwork covering all technology. The EMS provides no top level topological links.

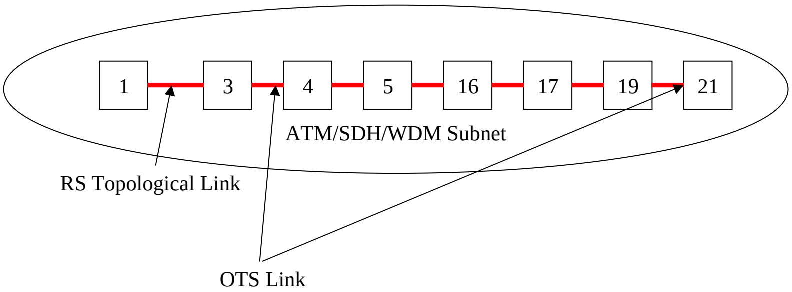


Figure 102 A single EMS and single multi-layer subnetwork

7.3 Topological links where there are multiple EML devices

The following example covers the case of two EMSs, one of which (Manager A) is managing the ATM NEs (1 and 21) within a single subnetwork and the other (Manager B) is managing the SDH/WDM NEs (3, 4, 5, 16, 17 and 19) within a single subnetwork. In this example both EMSs provide top level topological links that are off network and as a consequence report a remote address in the Z end of the link. It is quite acceptable for an EMS to not support the single ended links.

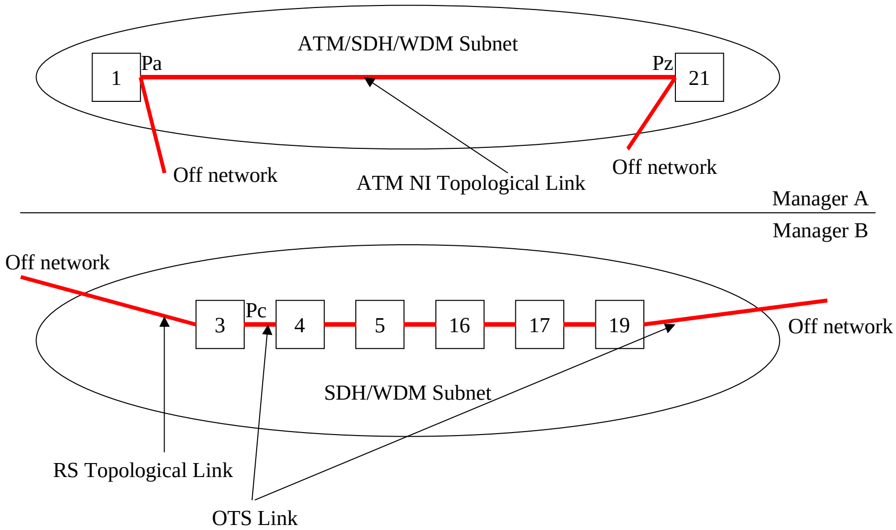


Figure 103 Two EMSs with mixed subnetworks

7.4 Topological links where there are multiple EML devices

The following example covers the case of two EMSs, one of which (Manager A) is managing the hybrid NEs 1 and 21 as ATM NEs within a single subnetwork and as SDH/WDM NEs in two separate subnetworks, the other (Manager B) is managing the remaining NEs (3, 4, 5, 16, 17 and 19) within a single (SDH/WDM) subnetwork. Both EMSs provides top level topological links that are off network.

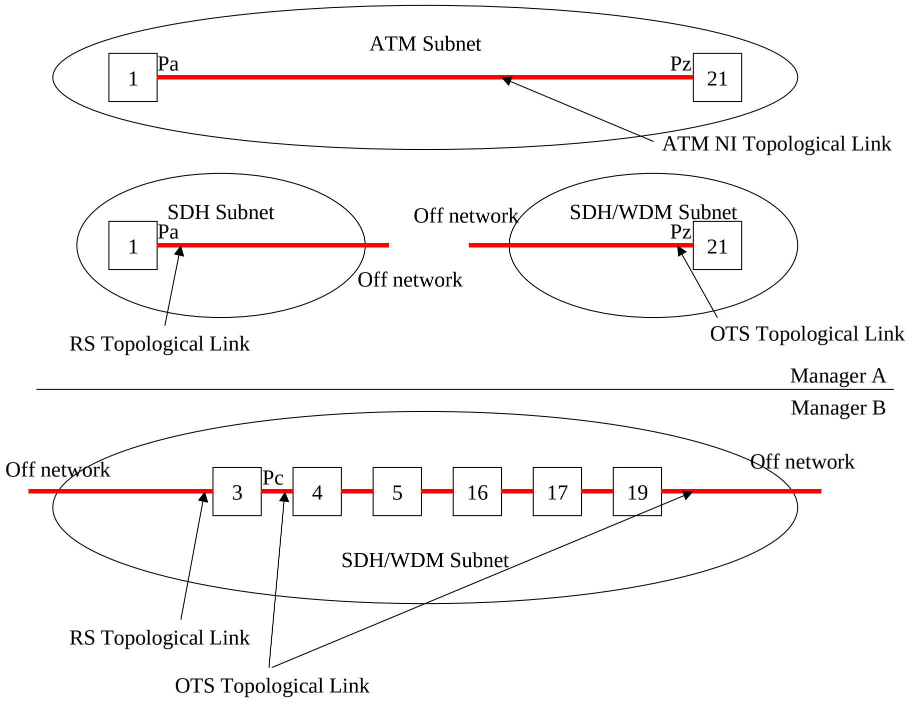


Figure 104 Two EMSs alternative

7.5 Topological links where there are multiple subnetworks

The following example covers the case of a single EMS managing the ATM NEs (1 and 21) within a single (ATM/SDH/WDM) subnetwork and the other NEs (3, 4, 5, 16, 17 and 19) within a single (SDH/WDM) subnetwork. The EMS provides top level topological links between the two subnetworks.

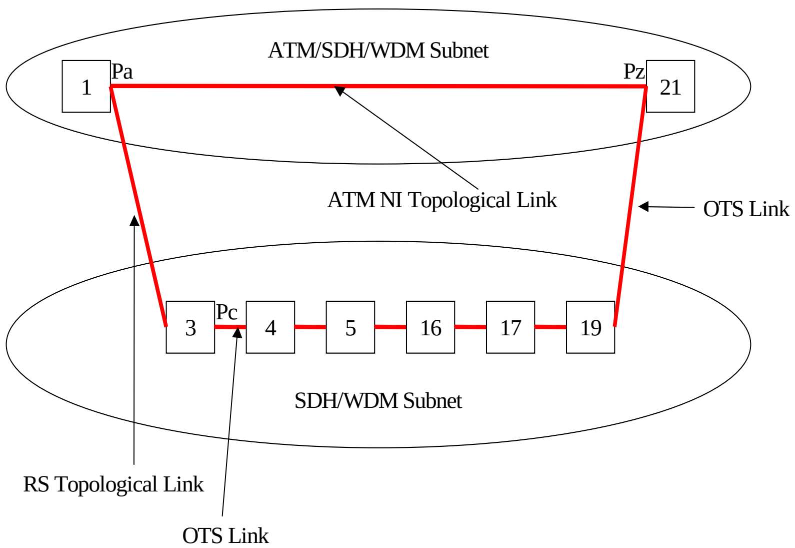


Figure 105 Single EMS with interconnected subnetworks

8 SNC VERSUS TL, TRAIL AND NETWORK CONNECTION MODELLING

Figure 106 (on page 106) depicts an extraction of components from ITU-T G.805 showing trails between access point (AP)s. The MTNM model currently does not explicitly model the ITU-T G.805 Trail. However, considering its definition and position, the MTNM Topological Link (TL) can be considered to represent the end-to-end essence of a G.805 Trail (see chapter 6 Topological Links on page 96 and chapter 7 Subnetwork Layering and Topological Links on page 103).

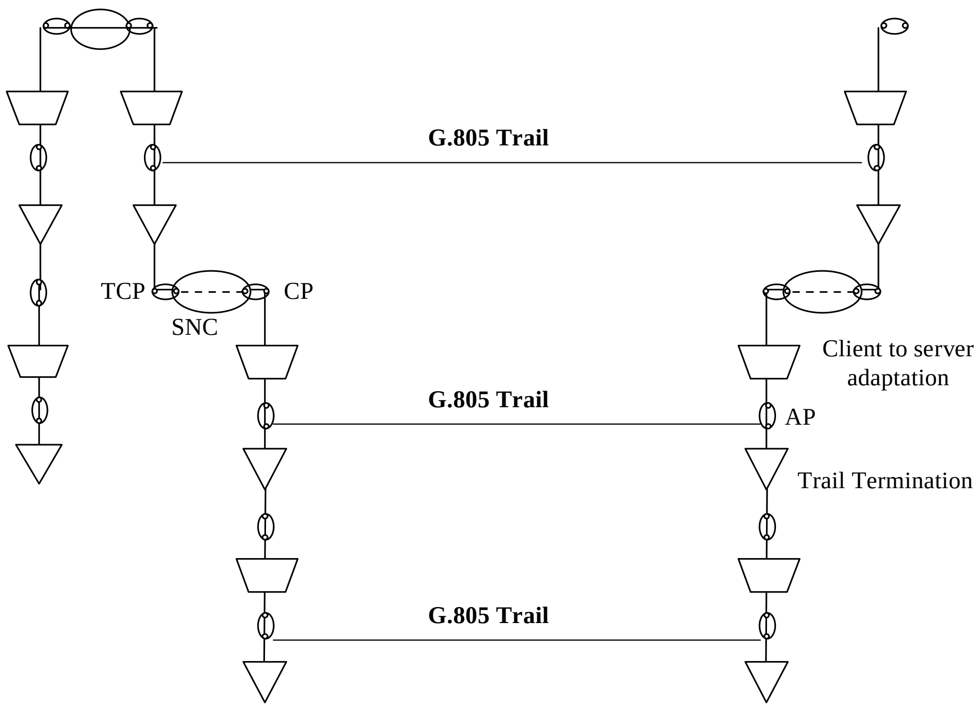


Figure 106 Extract of ITU-T G.805 Layered Model showing Trails

In the release 3 version of the MTNM interface the SNC capability was enhanced to allow the creation of an SNC to the TCP encapsulated in any MTNM TP to "encompass the Trail Termination function". Prior to release 3 it was only possible to create an SNC between the G.805 CP of a CTP (CTP type C, D and E in Figure 12 on page 23) or a G.805 TCP of a CTP that possessed no G.805 CP at the layer of connectivity (CTP type F and K in Figure 12 on page 23). It was not possible, for example, to create an SNC terminating on a PTP.

From release 3 onwards, however, an SNC may represent not only a G.805 Sub-Network Connection between CTPs, FTPs and GTPs but also a G.805 Network Connection (NC) between G.805 TCPs (sometimes called a "closed" NC), or between a G.805 TCP and a G.805 CP (sometimes called a "half-open" NC), that are encapsulated in any two MTNM TPs. Refer to Figure 128 on page 130 for the definition and relationship of G.805 Trails and NCs between the same TTPs.

As a consequence, an SNC may potentially be created between any TPs. At a Connection Matrix (CM) end point (a G.805 CP) the span of the SNC starts with a fixed or flexible connection through the ME at the SNC layer, i.e. the connectable layer of the end point. At a Link Connection (LC) end point the span of the SNC starts with a G.805 TCP with mapping mode set to TM_TERMINATED_AND_AVAILABLE_FOR_MAPPING if it is flexible (i.e., can be attached to a G.805 CP at the same layer). The default end point type is CM which is the only type available prior to release 3 (it is not necessary to indicate this default type, however an LC connection end point must be indicated). Intermediate route points of an SNC are always of the CM type (i.e., they are the end point of a fixed or flexible connection fragment).

This chapter shows all of MTNM's release 3 SNC capabilities in Figure 107 (on page 109) to Figure 122 Fully protected server SNC using FTPs on page 122. The figures also show SNCs terminating on PTPs or FTPs and highlight those SNCs that result from the SNC enhancement introduced in release 3 to encompass trail terminations.

The assembly of G.805 TT function and associated G.805 TCP, i.e. the G.805 TTP, is always encapsulated in the same MTNM TP. This implies that between the same two end points there can potentially be a topological link and a network connection or SNC (but not at the same time in the same subnetwork). However, these are different MTNM connection objects since they transport different signals. While a TL runs between G.805 access points and transports adapted information, an NC or SNC runs between TCPs or CPs and transports characteristic server-layer information (see also Figure 127 on page 129). An SNC between TTPs could be considered as a trail when the TT functions are meant to be encompassed.

It should be noted that the MTNM model has been extended further extended to support ASON Control Plane and that this section should be read in conjunction with the two ASON Control Plane supporting documents (SD1-45_ASONControlPlaneManagement-Primer.pdf and SD1-46_ASONControlPlaneManagement-Scenarios.pdf) for ASON Control Plane deployments.

8.1 Rules for SNCs and TLs

The enhanced SNC capability leads to the need to introduce a set of rules that govern the creation and deletion of SNCs and Topological Links as there is now a choice as to which entity to create between two TPs such that in some cases either entity could potentially be used.

To understand the rules it is important to first understand the distinction between the SNC and the TL using the concepts from G.805 (see Figure 1 Extract of ITU-T G.805 Layered Model and MTNM Simplification on page 12 and Figure 106 Extract of ITU-T G.805 Layered Model showing Trails on page 106).

The SNC:

- Is primarily for control of the network configuration and service provision
- Usually has routing details available in the layer of the SNC and often in the server layer(s)

  Note: There are cases of SNCs with empty route (see Figure 112 SNC without Crossconnects on page 114).
- Has a single dedicated layer rate but the layer rates of the crossconnections of its route(s) may refer either to this rate or to different server layers
- Is between G.805 TCPs and/or G.805 CPs of MTNM TPs (all four potential cases are possible)
- The end point of an SNC can be an edge TP only in the G.805 CP case, and so edge PTPs of type A (see Figure 11 PTP variety and layering on page 20) are never included in SNCs as they face out of the subnetwork
- Represents the essence of a G.805 SNC or Network Connection (NC)

The TL:

- Is primarily an administrative object used to convey a relationship between two TPs

  Note: Currently the MTNM model does provide means for creation and deletion of TLs but no means for TL provision in the sense of capacity management and link connection partitioning (i.e., channelization of TL capacities into link connections).
- Is used where there is no information (to the manager of the layer of the TL) on the relationship between the server layer termination relationship and connectivity
- Does not have any routing details except that it associates two peer end points
- Has a single dedicated layer rate
- Is solely created between G.805 TCPs of MTNM TPs (respectively between the hidden APs)
- Always represents the end-to-end essence of a G.805 Trail

There is a strong drive to constrain the number of objects visible at the MTNM interface to a minimum set to reduce the amount of data that needs to be transferred over the interface. For example, an EMS that provides an "Opaque View" of subnetworks to the NMS offers a minimum set of a subnetwork's resources that the NMS will need to see in order to manage the subnetwork (see section 8.2.16 on page 126).

As a consequence there is a drive to not duplicate information. So for an EMS to report a topological link between two TPs and an SNC between the same two TPs to the same NMS would appear to be wasteful. There is also a drive for consistent operation of the interface from vendor to vendor reducing variety and easing the task of integration and validation of conformance.

These drives in conjunction with the differences in definition of TL and SNC lead to the following rules:

- There should be no more than one SNC between a pair of TPs at any layer of the TPs as only one operation is required to associate the TPs via network routing
  - This SNC must be at a lower layer than any Topological Links between the same two TPs
  - The span of the SNC should include at least one of the following:

    A crossconnection in another ME between the two TPs that delimit the SNC

    A TP with flexible termination mode at the layer of the SNC

    A TP which is always terminated and mapped at the layer of the SNC

    A CTP of type F or K (see Figure 12 CTP variety and layering on page 23) (which can never be terminated and mapped)

    A variable Inverse Multiplexing function in the direct server layer (see section 3.11.5 TPs for Inverse Multiplexing (IM), Virtual Concatenation (VC), and IMA on page 46)
- There may be several Topological Links between two TPs, but for the layer set of any individual multi-layer subnetwork to which a TP belongs, there may be no more than one topological link to the TP per direction (see Figure 104 Two EMSs alternative on page 105 for a basic example).
- There should be no Topological Link between a pair of TPs if there is an SNC between that pair of TPs in a layer that is in the same multi-layer subnetwork (an SNC represents a trail when it encompasses the trail termination function at one or two ends).

Figure 107 Basic SNC and TerminationMode Capabilities(on page 109) to Figure 122 Fully protected server SNC using FTPs (on page 122) show abstract network examples of these rules and highlight cases that are illegal.

The rules identified have implications in a number of common network transition scenarios. There are examples highlighted in the following sections. It should be noted that as a result of any network transition the SNC and topological link configuration should abide by the rules highlighted.

8.2 Examples

Most of the following examples show very simple network cases. In reality there would be many more MEs involved between the terminating MEs, there may be complex server layer networks and there may be protection. Protection is shown in some of the later examples.

8.2.1 Basic SNC and Topological Link Model for singleton implementation

The following diagram shows the basic MTNM release 2 model for SNCs, TerminationMode and Topological Links for **a singleton implementation**. The diagram shows three MEs participating in a fragment of a trail. These capabilities are still available from release 3 onwards.

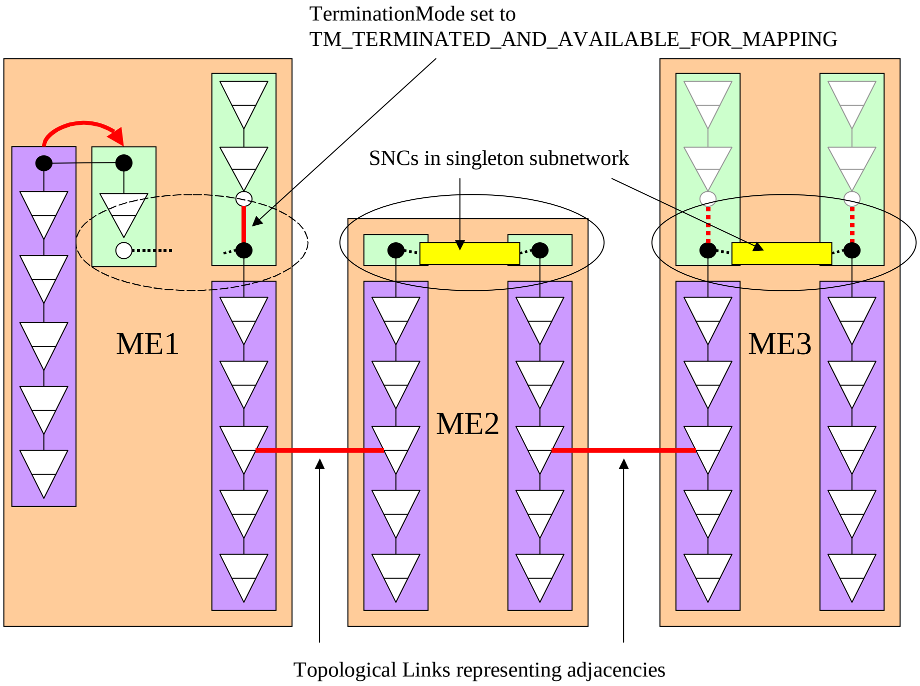


Figure 107 Basic SNC and TerminationMode Capabilities

So in a release 2 singleton implementation a fragment of a trail, when it cannot be represented as a TL, is represented by a sequence of MTNM objects comprising multiple MEs and consisting of adjacent singleton SNCs and a terminated and mapped CTP that is adjacent to the first (or last) SNC. The adjacencies of SNC end points and other edge TPs are represented by topological links below the SNC layers.

8.2.2 Basic SNC and Topological Link Model for mesh subnetwork

The following diagram shows the basic MTNM release 2 model for SNC, TerminationMode and Topological Links for **a mesh subnetwork**[14]. The diagram shows three MEs participating in a full trail that is made up of the combination of the SNC and the two TerminationMode settings on the CTPs. Instead of only ME2 there could be any reasonable number of MEs belonging to the shown subnetwork each having a crossconnect that participates in the SNC and therefore in the trail.

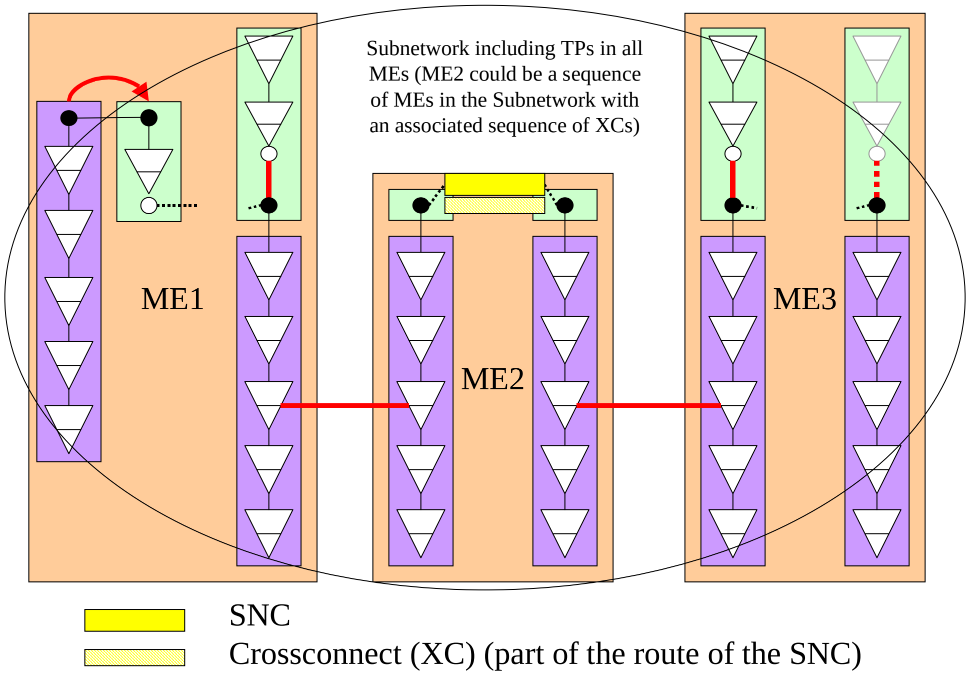


Figure 108 Connection between two Termination Functions using Release 2.1 Capabilities

So in release 2 an end-to-end trail, when it is not represented as a Topological Link, is represented by a combination of zero or more SNCs in the zero or more intermediate MEs (in the example there is a single SNC in the single intermediate ME) and two adjacent, terminated and mapped CTPs where the adjacencies are represented by Topological Links below the SNC layer.

[14] It should be noted that the MTNM model has been extended to support ASON Control Plane and that this section should be read in conjunction with the two ASON Control Plane supporting documents (SD1-45_ASONControlPlaneManagement-Primer.pdf and SD1-46_ASONControlPlaneManagement-Scenarios.pdf) for ASON Control Plane deployments.

8.2.3 Extended SNC Model (for mesh subnetwork)

The following diagram shows the extended MTNM release 3.0 model for SNC. The SNC extends to cover not only the crossconnects but also the Trail Termination functions respectively TCPs of the two CTPs that terminate the trail. In release 2 implementations the shown CTPs could not be end points of SNCs. Instead of only ME2 there could be any reasonable number of MEs belonging to the subnetwork each having a crossconnect that participates in the SNC and therefore in the trail.

Note that **the SNC enhancement cannot apply to a singleton implementation**[15] since this cannot offer a subnetwork that hosts the end-to-end trail, and so the new type of SNC end point (the LC end points) does not apply for singleton implementations. In other words, in case of singletons, where every SNC is an XC, the SNC end points must encapsulate a G.805 CP or a G.805 TCP at the layer of connectivity.

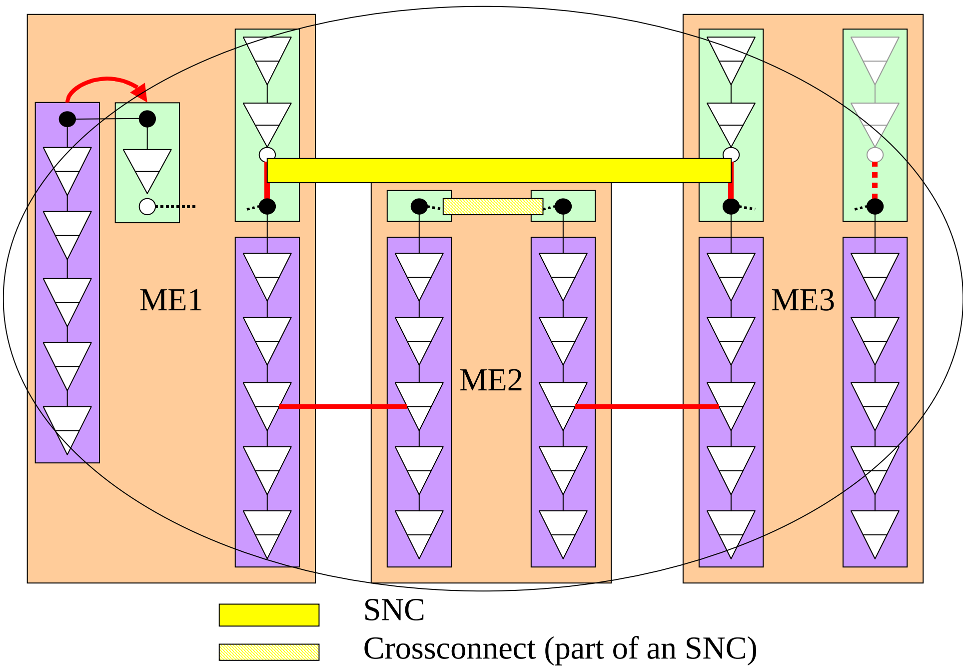


Figure 109 Connection between two Termination Functions using Release 3.0 Enhancement

[15] Therefore it is not necessary to indicate the endpoint type CM/LC for a singleton subnetwork implementation as the endpoint type is always CM which is the default.

8.2.4 Extended SNC Model with Example of Illegal SNC

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting an illegal case. It contradicts the rules set forth and recommended in section 8.1 Rules for SNCs and TLs on page 107.

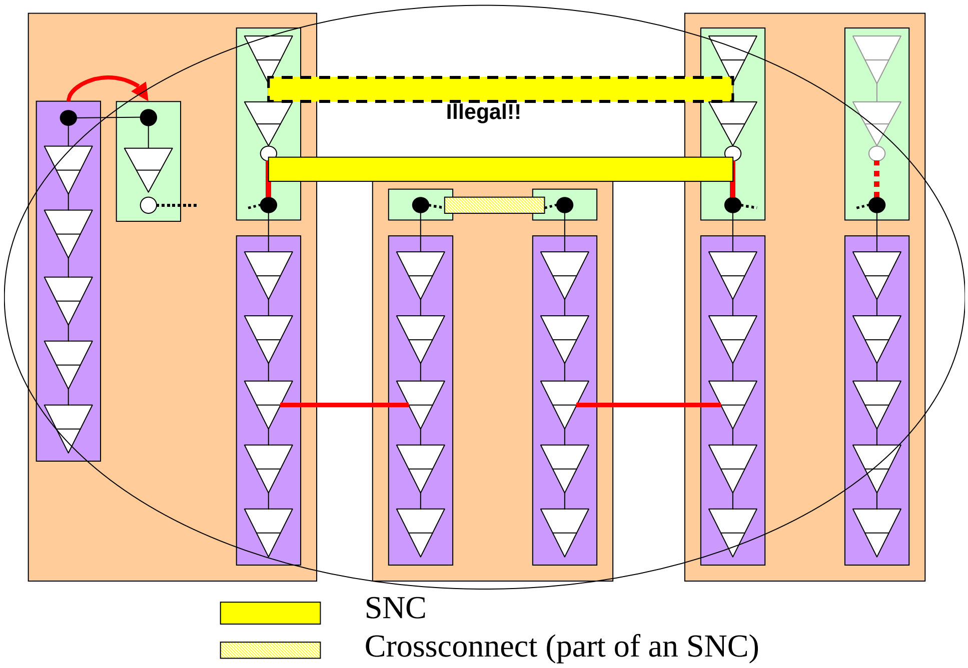


Figure 110 An illegal SNC

8.2.5 Extended SNC Model with Topological Link above SNC

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where a topological link is created above an SNC. This case is particularly applicable to Ethernet deployments (see SD1-44_ConnectionlessTechnologyManagement.pdf).

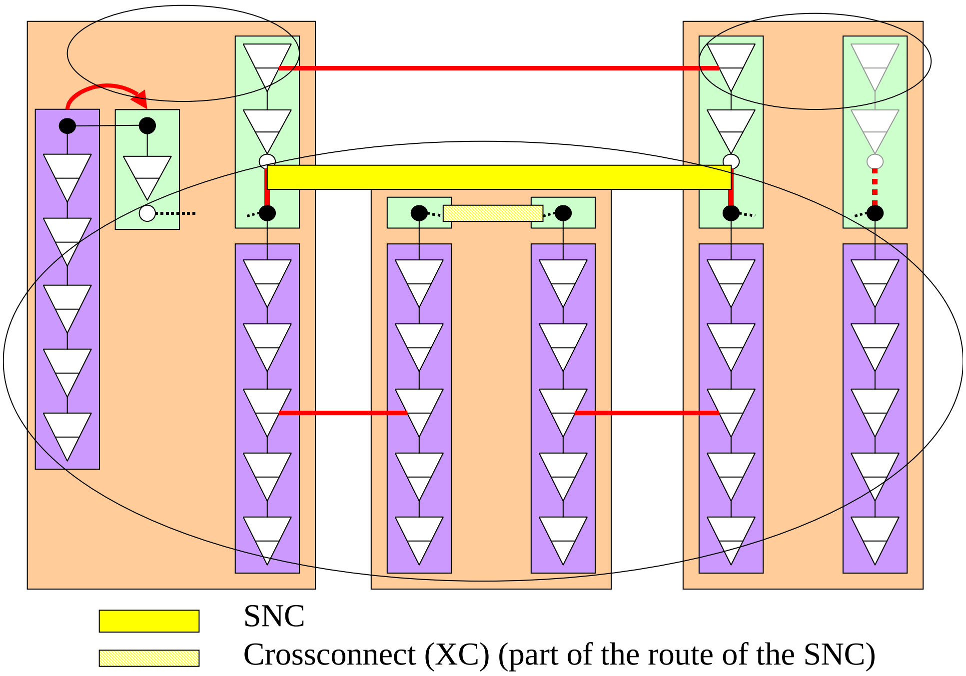


Figure 111 Topological Link and SNC Combination

8.2.6 Extended SNC Model with SNC having no Crossconnects

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where an SNC route only includes two TerminationMode settings and no crossconnects.

However, instead of modelling a G.805 network connection with an MTNM Sub-Network Connection it could also be modelled, at the same layer, by an MTNM Topological Link. But according to the rules set forth in section 8.1 Rules for SNCs and TLs on page 107, there cannot be an SNC and a TL at this layer at the same time in the same multi-layer subnetwork. See also section 8.2.9 Extended SNC Model showing two SNCs on top of each other on page 117 regarding illegal SNCs that duplicate TLs (on different layers).

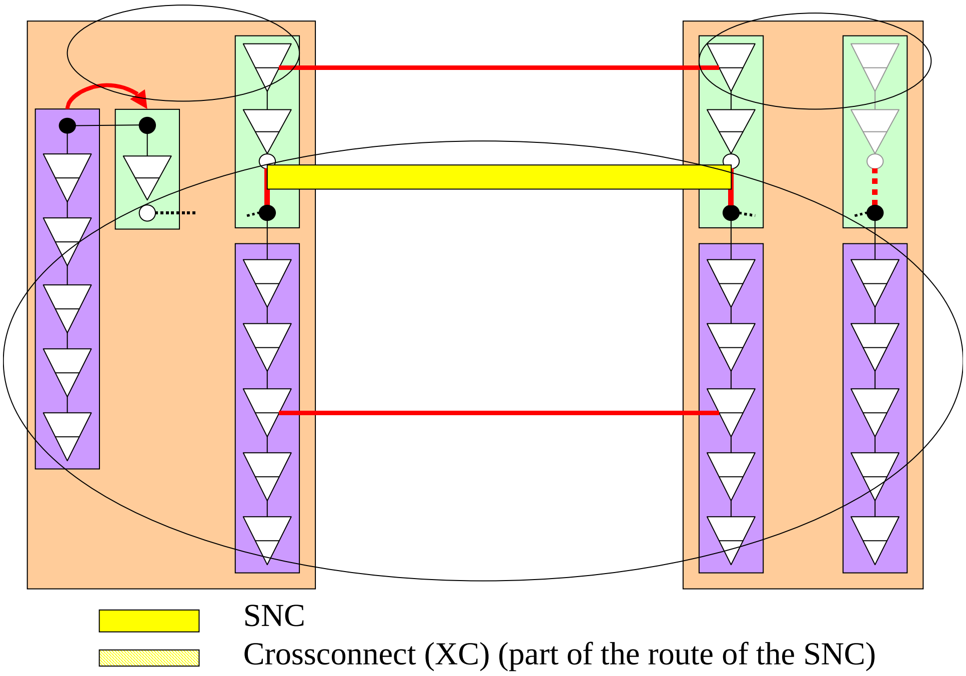


Figure 112 SNC without Crossconnects

8.2.7 Extended SNC Model with SNC to TCP at one end

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where an SNC (e.g., in the Lower Order VC3 layer) is created to a G.805 TCP via a crossconnect at one end (CM end point; this was possible using MTNM release 2.1) and a G.805 TCP via a TerminationMode setting respectively an LC end point at the other end (this is an MTNM release 3.0 extension). Considering the example in more detail this could be showing an OC1 port in the left hand NE that terminates to produce a single DS3 that is remultiplexed into a Low Order VC3 and crossconnected across the network via and STM1 network (therefore the VC4 is encapsulated in the PTPs) to terminate in the right hand NE on a CTP that extracts the DS3 signal, terminates it and further demultiplexes it to produce some client signal (not shown in the diagram).

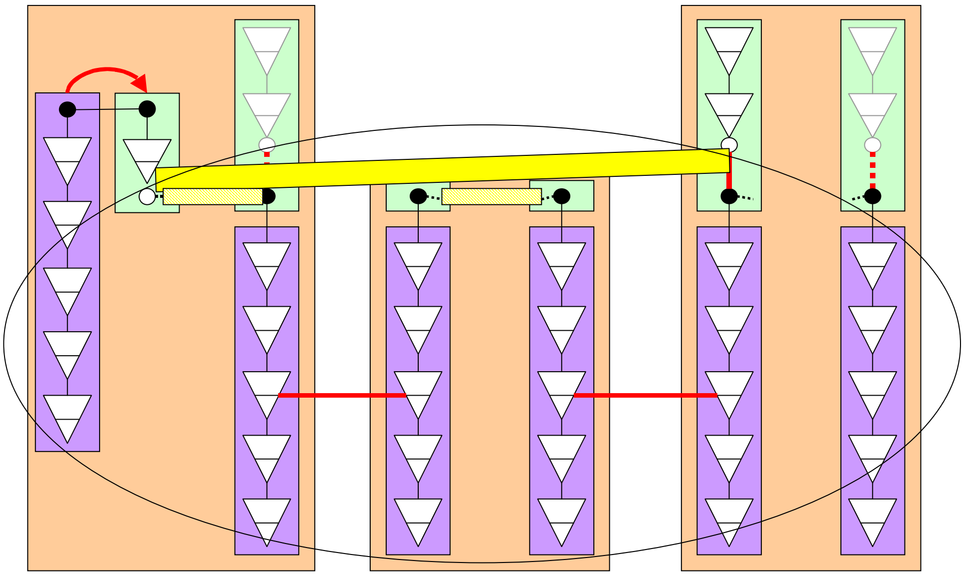


Figure 113 SNC crossing ME to TCP

8.2.8 Extended SNC Model showing Illegal SNC and Correction

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where an SNC is incorrectly formed (as it terminates on the network side of a connected G.805 CP).

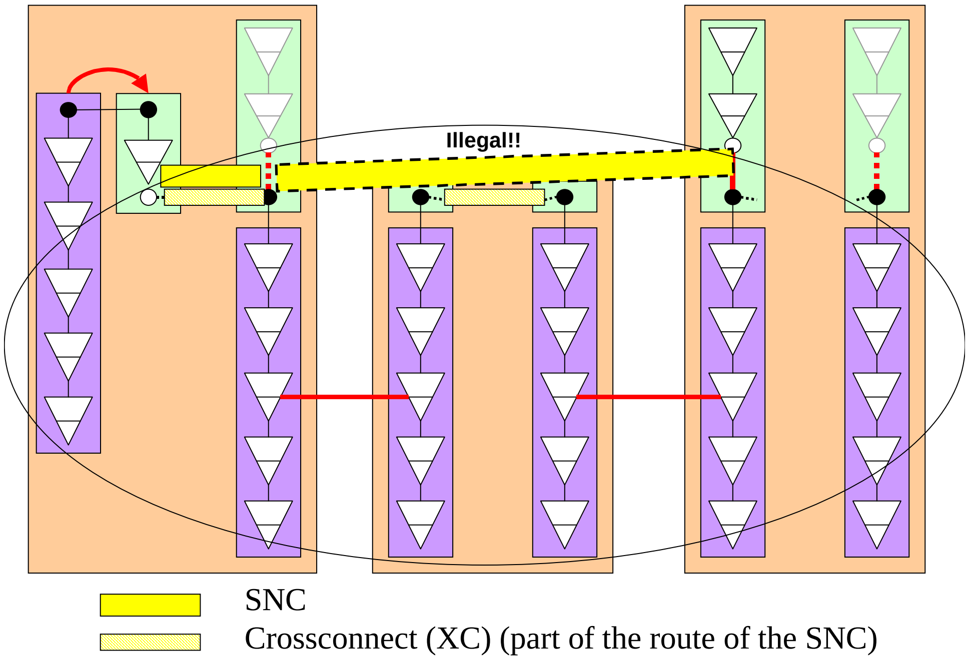


Figure 114 SNC terminating illegally on the external face of a CP

And here is the correct form of the SNC if fragmented. The two SNC fragments could be replaced by a new single SNC as shown in Figure 113 (on page 115).

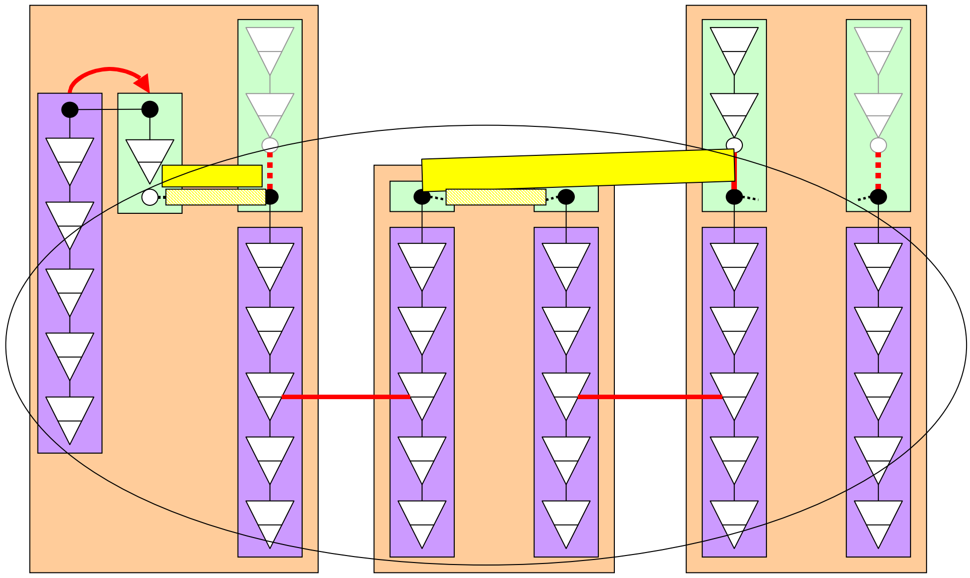


Figure 115 A valid form of SNC configuration for the case covered in Figure 114

8.2.9 Extended SNC Model showing two SNCs on top of each other

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where an SNC exists at two layers above the same physical ports.

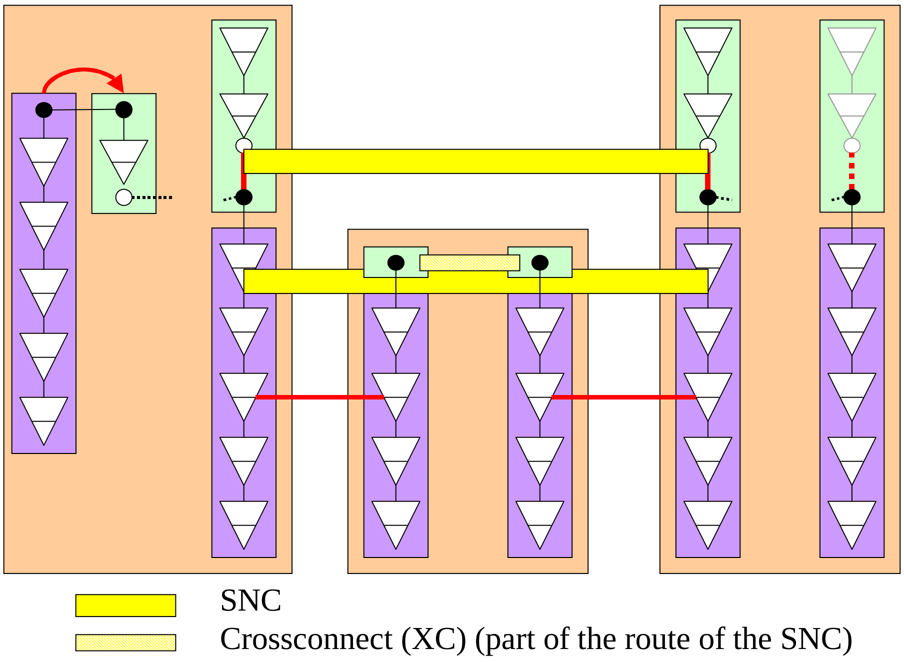


Figure 116 Two layers of SNC legally formed

And the next diagram shows the implications of removal of the intermediate ME.

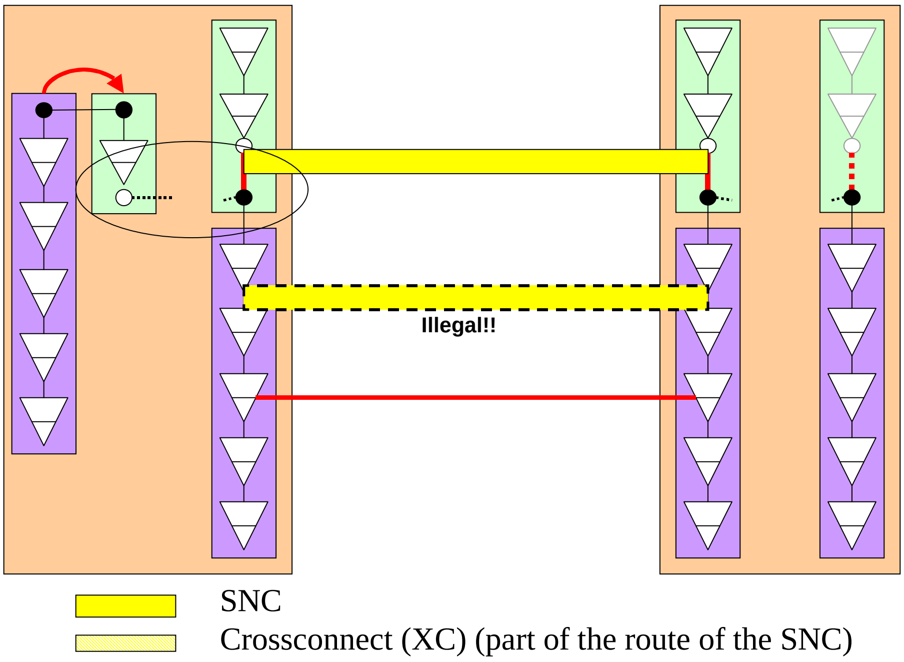


Figure 117 After ME removal the lower SNC is a duplicate of the TL and so is illegal

And a further diagram shows the implications of un-terminating and crossconnecting one or both of the end points of the upper SNC. In that case traffic can only be conveyed across the lower SNCs and clearly the upper SNC is no longer representative of any network flow and as a consequence is illegal.

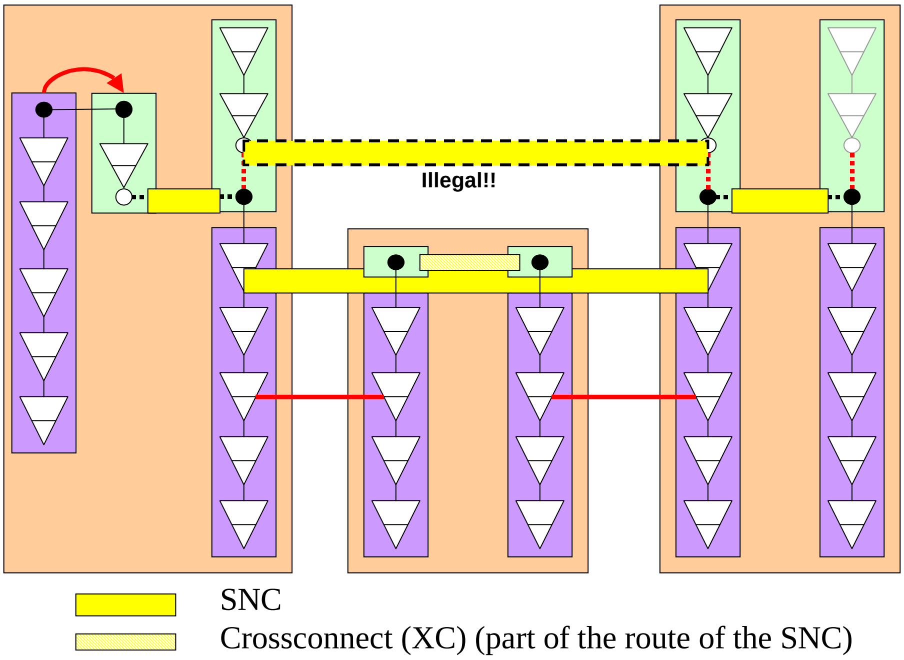


Figure 118 After crossconnecting its end points the upper SNC is illegal

8.2.10 Extended SNC Model showing TP Relationship as part of a route

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where an SNC route includes a TP containment relationship (in a server layer).

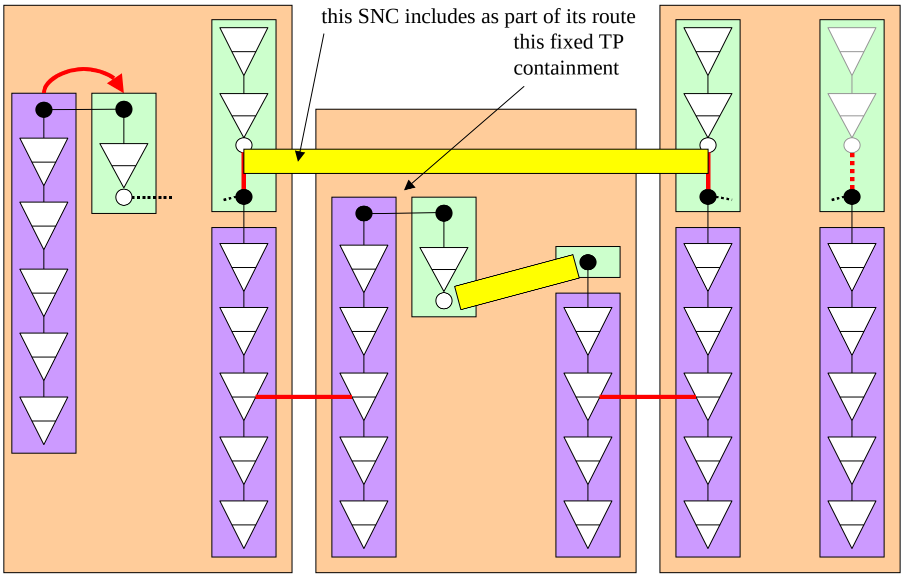


Figure 119 SNC including a fixed TP relationship in its layer as part of its route

8.2.11 Extended SNC Model with SNC and Topological Link between FTPs

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where an SNC (i.e., a network connection) and a topological link (i.e., a trail) exist between two FTPs at the same time. Note that the SNC and topological link work at different multi-layer subnetworks. For example, the FTPs could represent peer IMA groups with the topological link representing the IMA Virtual Link composed of the supporting physical IMA links as shown in Figure 76 on page 80. This case is particularly applicable to Ethernet deployments (see SD1-44_ConnectionlessTechnologyManagement.pdf).

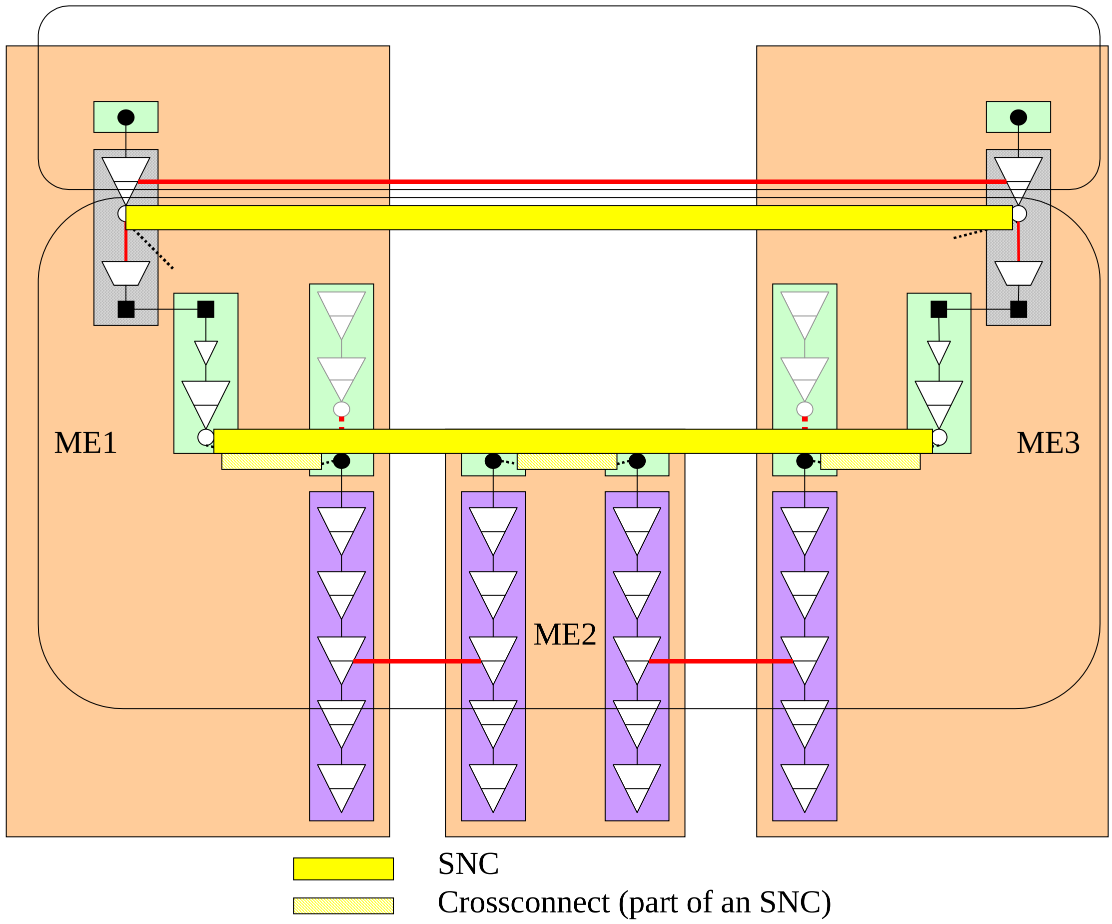


Figure 120 SNC and TL between FTPs

8.2.12 Extended SNC Model showing SNC Protection between FTPs

The following diagram shows the basic MTNM release 2 model for end-to-end protection of a server SNC with protection type SNCP (see SD1-36_SNCTypes.pdf). Here a "server SNC" is defined as an SNC, or a trail rather, which does not support service directly but is an infrastructure used to support end-to-end customer service providing SNC provisioning. There clearly may be many layers of “server” SNC providing infrastructure for the eventual end user signal. In the shown protection scheme, the core server SNC is fully protected but the entire server SNC, i.e. the end-to-end trail built from the core server SNC by terminating and mapping adjacent CTPs in ME1 and ME3, is only partially protected. The protection does not cover the possibility of a "fibre cut" of one or both of the topological links between ME1 and ME1a or between ME3a and ME3.

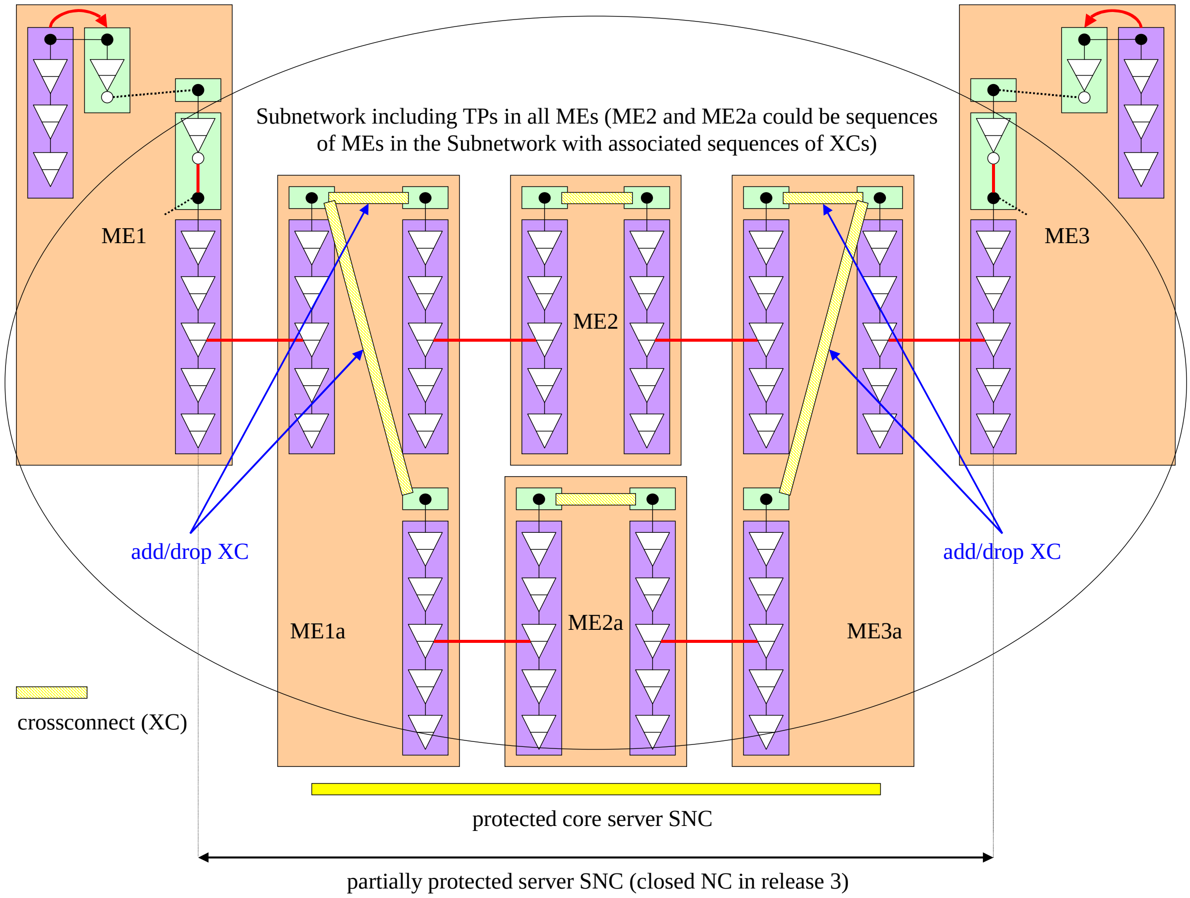


Figure 121 Partially protected server SNC (Release 2)

Using release 3 capabilities, a fully protected end-to-end infrastructure trail can be provisioned and separate network elements for the add/drop XCs are not needed.

The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where SNC protection exists between two corresponding floating TPs (which are like PTPs always terminated and mapped at the client side). This SNCP represents the end-to-end protection of a server SNC which is in fact an infrastructure trail. Add/drop XCs are used to connect each FTP with edge CTPs, and TLs connect the corresponding edge PTPs to the peer MEs where the core serving SNC starts respectively ends. The worker route and protecting route use different edge PTPs and therefore different TLs to reach a high degree of protection against topological link failures such as fibre cut. In large networks the server SNC could comprise multiple subnetworks with add/drop SNCs in the outer subnetworks and simple SNCs in the inner subnetworks. Such an SNC is called "NMS server SNC" since it needs to be stored at the NMS and is built from fragment SNCs that may be stored at multiple EMSes.

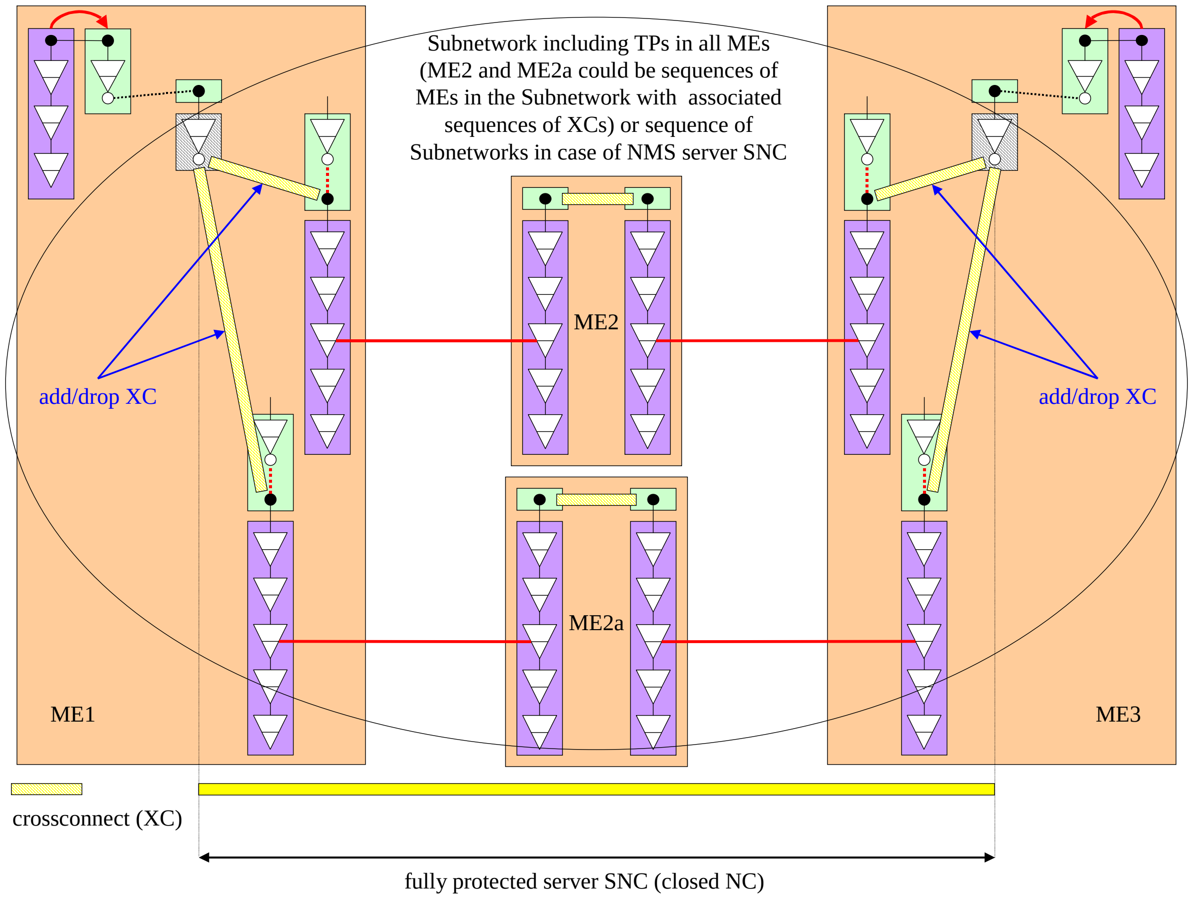


Figure 122 Fully protected server SNC using FTPs

8.2.13 Topological Links and SNCs for OTN Network

Figure 123 Starting point with SNC and Topological Links on page 123 shows an example of links between some of the ports of the NEs in Figure 93 Network Diagram for Topology Discussion on page 97. It is assumed in the figure that the MEs can discover OTS adjacencies (and therefore discover their neighbours in the OTS layer).

The figure shows three SNCs that extend to the TCPs of the PTPs in the OMS, OCH and DSR layers. The trail represented by the SNC in the OMS layer between NE10 and NE12 negates the need to report a topological link over which the SNC between NE6 and NE13 is effectively carried.

All the SNCs in this network could be classified as "server" SNCs as defined in section 8.2.12 Extended SNC Model showing SNC Protection between FTPs on page 121.

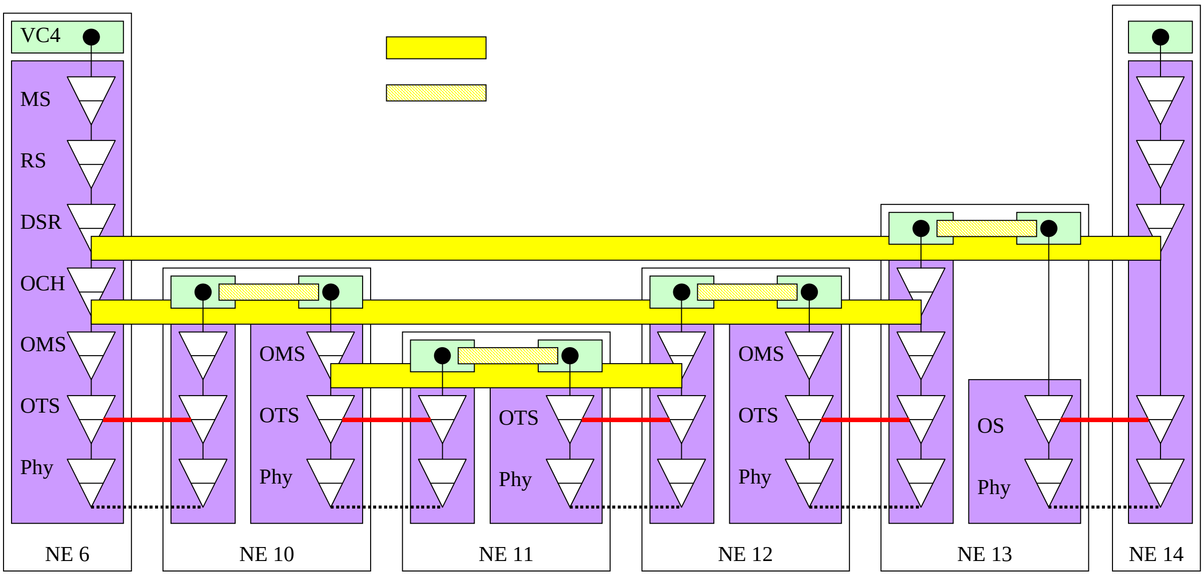
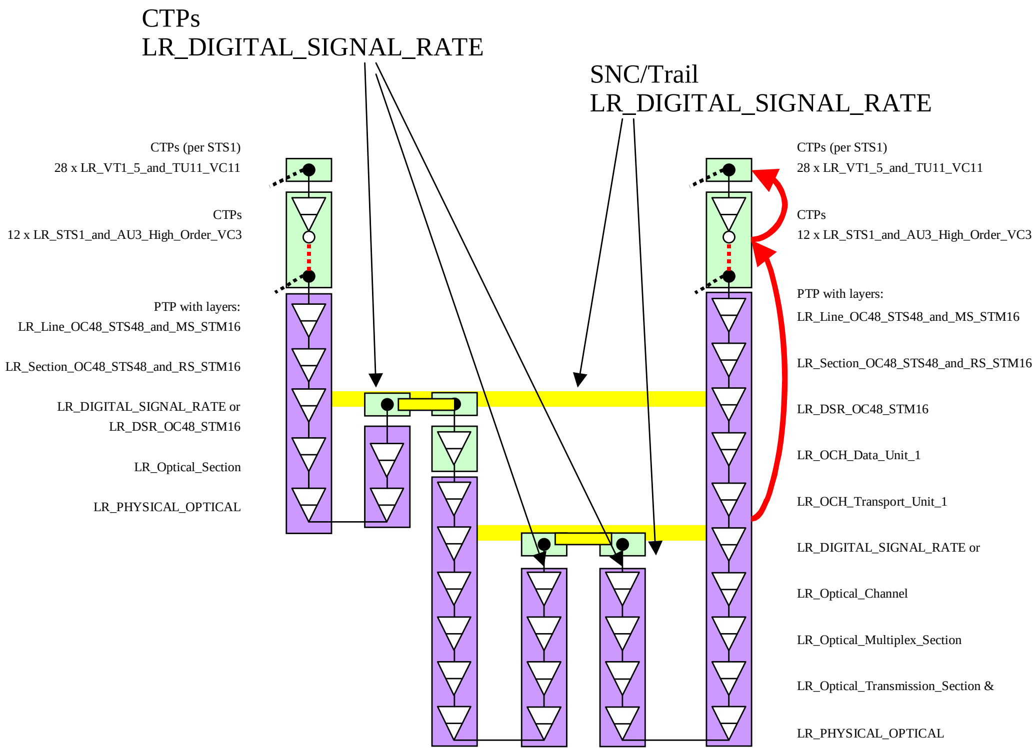


Figure 123 Starting point with SNC and Topological Links

8.2.14 Repeated DSR layer in a single TP in an OTN Network

The following figure shows the case of repeated DSR layer in a single PTP. The PTP represents a single channel optical port that that has full WDM capability. The network diagram shows the need for the two DSR layers from a network compatibility perspective.



8.2.15 Topological Links and SNCs for Ethernet Ports

Figure 124 Ethernet topological links and SNCs when using Inverse Multiplexing on page 125 shows an SNC between the Encapsulation TPs. In this case there are no crossconnections or Topological Links in the layer of the SNC between the Encapsulation TP. This SNC is allowed as a result of the multiple parallel Fragment layer Trails. The Fragment trails are not represented at the MTNM interface as their entire route is described by the VT1.5 trails that themselves are represented by parallel SNCs. Relating this to section 8.2.12 Extended SNC Model showing SNC Protection between FTPs on page 121, the Vt1.5 SNCs are “server” SNCs to the Fragment and indirectly to the Encapsulation layers’ SNCs. The Encapsulation layer SNC is itself a “server” SNC to the Ethernet SNC (which in this case may be providing direct customer service).

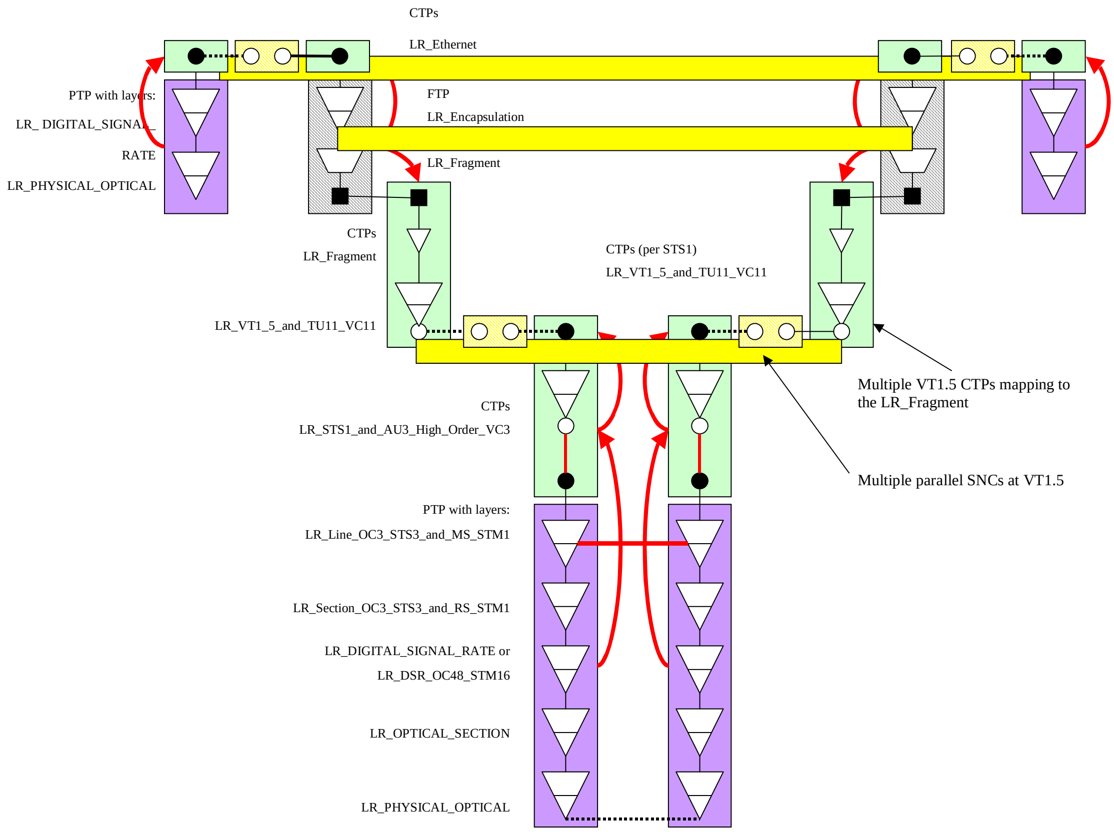


Figure 124 Ethernet topological links and SNCs when using Inverse Multiplexing

8.2.16 Extended SNC Model used for Opaque View Implementation

The intent of an NMS opaque view (sometimes referred to as a cloud or edge or subnetwork view) is to provide a convenient abstraction of the network and its subnetworks to the NMS. The idea is to provide the NMS with a minimum set of a subnetwork's resources that it needs to see (and, optionally, to provision) in order to manage the subnetwork, in particular regarding connection management. Treating subnetworks as big MEs reveals the fact that certainly edge PTPs and their contained CTPs as well as (release 3) SNCs between edge TPs will belong to this minimum set for each subnetwork.

If edge points can only be connected by using cross connections at different layers, the NMS will require some knowledge of internal details of subnetworks (the specific internal details are listed below). As a rule a server SNC needs to be provisioned first on a lower (higher order) layer that provides higher layer (lower order) capacity, i.e. has its end points terminated and mapped (and thus is equivalent to a trail). In large networks such a server SNC may be distributed across several subnetworks that are interconnected by topological links belonging to the SNC's route. Then there are outer SNC fragments that have only one end point encompassing a trail termination function; they are called **half-open trails**. The following diagram shows the extended MTNM release 3.0 model for SNCs highlighting a case where two half-open trails (or network connections rather), represented by SNCs, are connected by TLs to an ordinary release 2 SNC to form an end-to-end trail (server SNC).

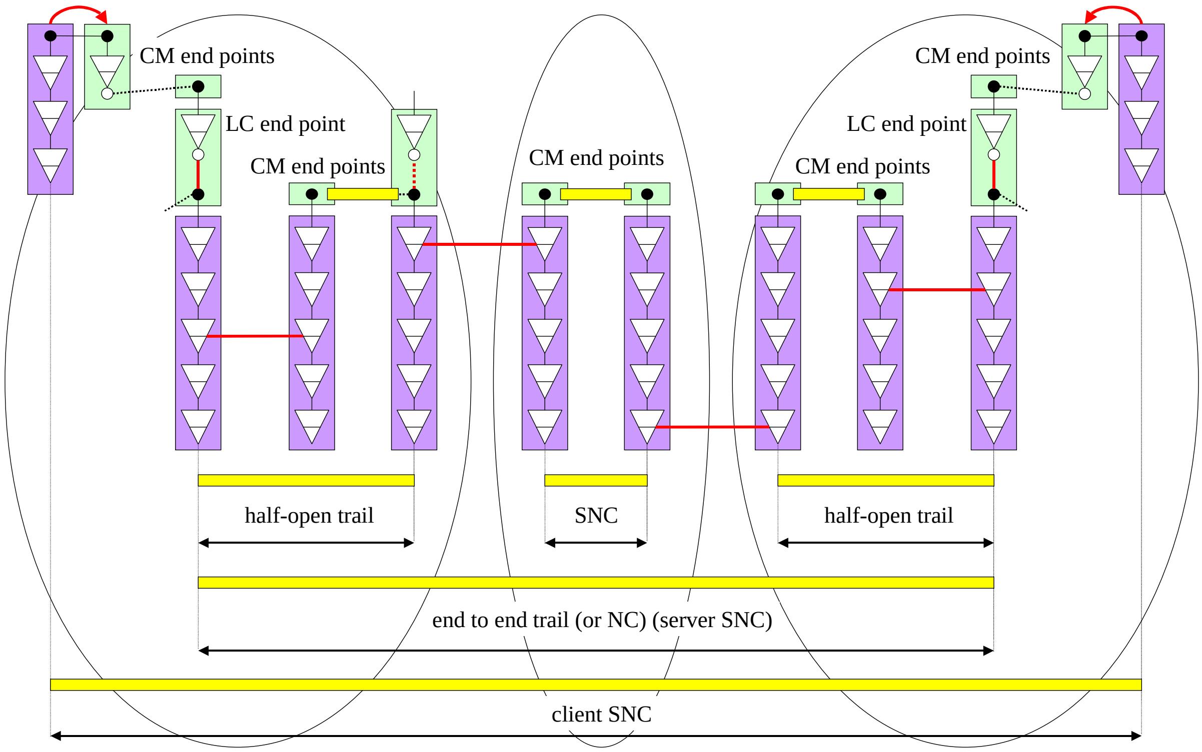


Figure 125 End-to-end trail made of two half-open trails and an ordinary SNC

Refer to section 8.2.12 (on page 121) and Figure 122 (on page 122) for the more subtle case of SNCP provisioning by means of add/drop SNCs that results in a fully protected end-to-end trail.

8.3 Implications of Opaque View and Multiple Layers of a Management Hierarchy

It should be noted that it is quite possible for the interface described in this solution set to be used at several layers in the management hierarchy of a particular deployment. So in a large network it is possible that an OSS uses this interface to manage an NMS that again uses this interface to manage an EMS. In this case the SNCs represented at the NMS to OSS interface may consolidate several SNCs represented at the EMS to NMS interface. An SNC that is a “client” SNC from an EMS perspective may be a “server” SNC from and

NMS perspective. Since server SNCs are part of the route of any client SNC they establish a client/server relationship between SNCs on adjacent layers which corresponds to the (one-to-one, many-to-one, one-to-many) G.805 relationship of the layers themselves. This relationship could be refined by the introduction of link connections.

An **NMS opaque view**, as opposed to a detailed view, comprises the following resources **per subnetwork**:

- All edge PTPs (and edge FTPs if applicable) and their contained CTPs
- All (release 3) SNCs between edge TPs
- All half-open trails ending at an edge TP at their open side (i.e., the un-terminated side)
- All interior end points of half-open trails (PTPs, FTPs, CTPs) and their contained CTPs
- Optionally containing TPs, supporting equipment objects, and containing MEs of such interior end points

When an NMS opaque view is offered by the EMS there must be means to discover, and optionally to provision, half-open trails in addition to SNCs between edge TPs, and potential or actual interior end points of half-open trails in addition to edge TPs. Such means are conceivable but are not part of the current release of the MTNM interface. For example, when creating a half-open trail edge TPs of client SNCs, which shall be connectable to contained TPs of the yet unknown interior end point, could be supplied as a kind of routing inclusion constraints (see attribute `neTpInclusions` of `SNCCreateData_T`). This mechanism would generalize the provisioning of closed trails by TerminationMode settings (see section 8.2.2 on page 110 and section 8.2.6 on page 114). The EMS may also offer, for the convenience of the NMS, an EMS assignment capability for interior end points of half-open trails (as explained in section 8.2.12 on page 121).

8.4 Multiple topological links in the same subnetwork

An ATM link, i.e. a top level or inner TL between peer ATM NI CTPs, is used to transport VP traffic and "VC without VP" traffic between ATM NEs (e.g., NE1 and NE3). The ATM link capacity is used to support ATM VP trails within ATM subnetworks. The EMS could expose a VP trail as a topological link since it is a component of the ATM infrastructure used for VC traffic (PVCCs or SVCCs). In release 2 of the MTNM interface the trail is created as a "server SNC" between two ATM VP CTPs, which is extended on both ends by two further ATM VP CTPs that are terminated and mapped. The trail therefore consists of a VP SNC and two terminated VP CTPs.

Each terminated CTP is made adjacent to its counterpart CTP (which is connected) by a topological link at its server layer that needs not be exposed at the MTNM interface. But the whole VP trail between the two terminated VP CTPs should be exposed as a topological link at the ATM VP layer; this is possible in release 3 (see chapter 8). The same TL is used for all VP trails served by the same network interfaces.

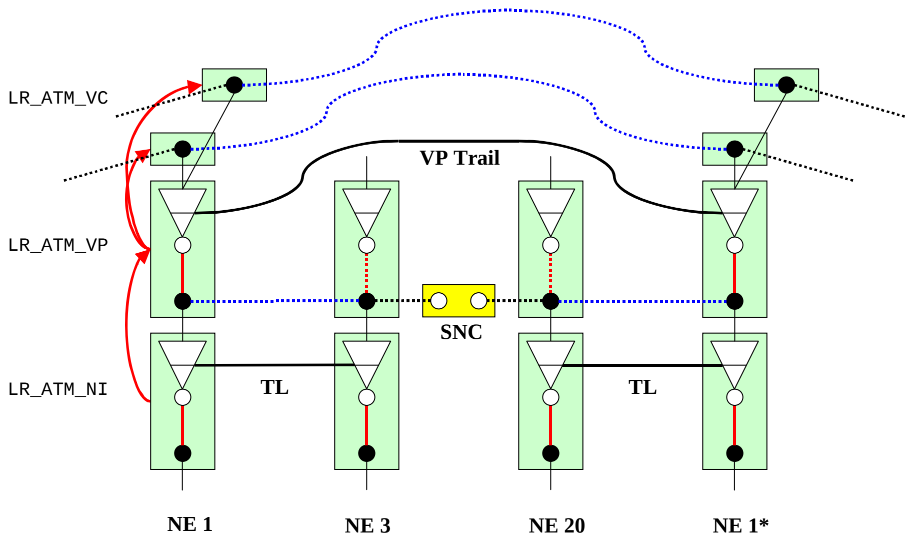


Figure 126 ATM VP trail supported by ATM links and ATM VP SNC

The blue dotted lines in the figure represent G.805 link connections (LCs) that are not modelled in the MTNM interface. The VP LCs partition the NI topological links (ATM links) while the VC LCs partition the VP trails. The link connections need not be provisioned separately but VP/VC link connections become available when peer ATM NI/VP CTPs are terminated and mapped. VC LCs and SNCs convey VC layer characteristic information (CI) consisting of VC layer adapted information (AI) and F5 OAM information. VP trails convey VP layer AI (which includes multiplexed VC layer CI), and VP LCs and SNCs convey VP layer CI consisting of VP layer AI and F4 OAM information.

Note that the ATM NI CTPs shown in the figure could also be IMA Groups represented by FTPs. Then the adjacency topological links between peer IMA groups represent IMA Virtual Links.

ANNEX INTRODUCTION TO G.805

A transport network conveys telecommunications information between locations. In concrete environments this information is a signal with a technology-dependent format, and, optionally, a specific transmission rate (bandwidth), which is transmitted or received on network connections or in a connectionless way. ITU-T's Rec. G.805 (*Generic Functional Architecture of Transport Networks*, March 2000) considers each specific signal to be bound to a connection-oriented *transmission layer* and introduces the term *characteristic information (CI)* for the signal. It decomposes the transport network into a number of independent single layer networks with a client/server association between hierachically adjacent layer networks. Each layer network can be separately partitioned in a way, which reflects its internal structure or the way that it will be managed. Thus the concepts of partitioning and layering are orthogonal: a downwards vertical transmission layering is supplemented by a recursive horizontal layer network partitioning. A single layer network describes the generation, transport, and termination of a particular characteristic information.

Layer networks are partitioned into appropriate subnetworks and links between them, and subnetworks and links may be further partitioned. The links are a representation of the resource provided to the layer by its server layer networks. A network partitioning implies the connection partitioning of its network connections into tandem connections, i.e. alternating sequences of *subnetwork connections (SNCs)* within subnetworks and *link connections (LCs)* between subnetworks.

In the client/server relationship of adjacent layer networks, client layer LCs are supported by server layer trails (one-to-one, many-to-one, one-to-many) through an *adaptation* that modifies the CI of the client layer so that it can be transported over the *trail (= network connection with trail terminations at both extremities)* in the server layer network. A signal that is transmitted or received on a trail is called *adapted information (AI)*. The trail is built from the underlying tandem connection by means of a *trail termination source/sink* that generates CI/AI by adding/extracting a trail overhead to/from the information it transmits/receives. The trail overhead allows performance monitoring of the trail and ensures the integrity of information transfer.

A one-to-one client/server relationship represents the case of a single client layer LC supported by a single server layer trail. The many-to-one relationship represents the case of several LCs of client layer networks supported by one server layer trail at the same time. Multiplexing techniques are used to combine the client layer signals. The one-to-many relationship represents the case of a client layer LC supported by several server layer trails in parallel. Inverse multiplexing techniques are used to distribute the client layer signal.

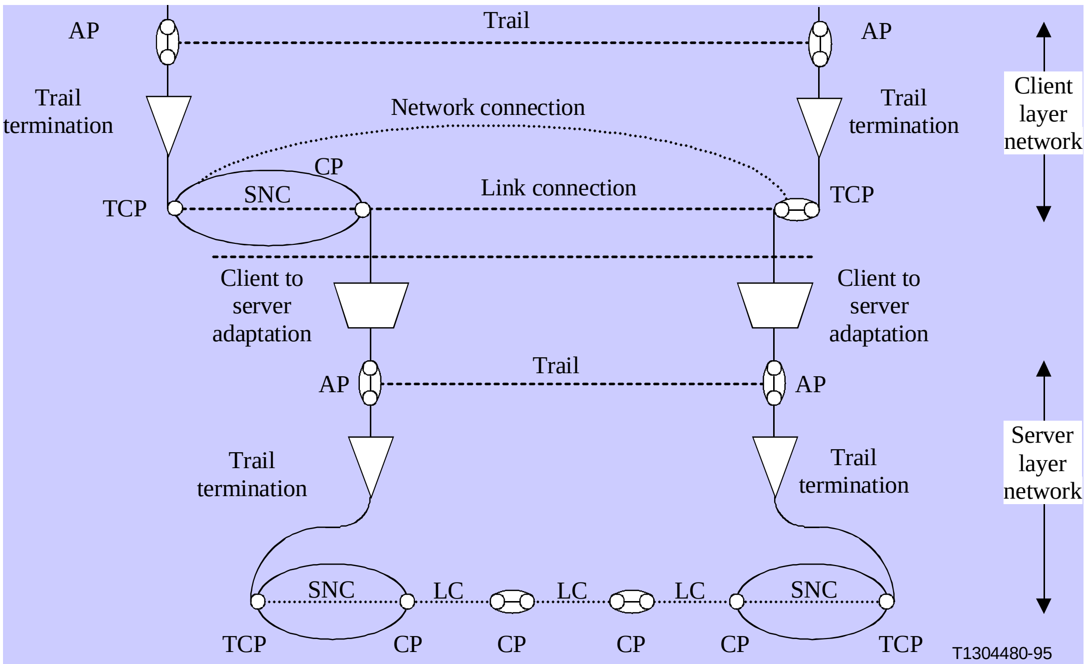


Figure 127 Basic G.805 Modelling Concepts

Reference points are formed by the binding between inputs and outputs of adaptations and/or trail terminations and/or transport entities. Bindings represent static connectivity that cannot be directly modified by management action. Each transport entity is delimited by accompanying reference points: LCs and SNCs by *connection points (CPs)* or *termination connection points (TCPs)*, and trails by *access points (APs)*. Figure 127 (on page 129) (which is Figure 3/G.805) provides an overview of the different pipe and reference point concepts used in connection-oriented TMN functional models.

Figure 128 (on page 129) (which is Figure 2/G.852.2) provides an overview of the corresponding enterprise-wide network resource concepts. ITU-T's Rec. G.852.2 (*Enterprise Viewpoint Description of Transport Network Resource Model*, March 1999) specifies a set of definitions of management abstractions of G.805 transport network architectural components; these abstractions are termed *network resources* and the resulting transport network resource model is termed *Transport Network Enterprise Model (TEM)*. The most important resources are the *Connection Termination Point (CTP)* and the *Trail Termination Point (TTP)*. The CTP is the assembly of the CP resp. TCP and the client-layer part of the accompanying adaptation. The TTP is the assembly consisting of the trail-termination part of the TCP and the accompanying trail termination together with the server-layer part of the adaptation and hence together with the AP. Figure 128 (on page 130) shows that in the TEM, CTPs are the delimiters of link connections and TTPs are the delimiters of trails, while TCPs are the delimiters of network connections as in G.805.

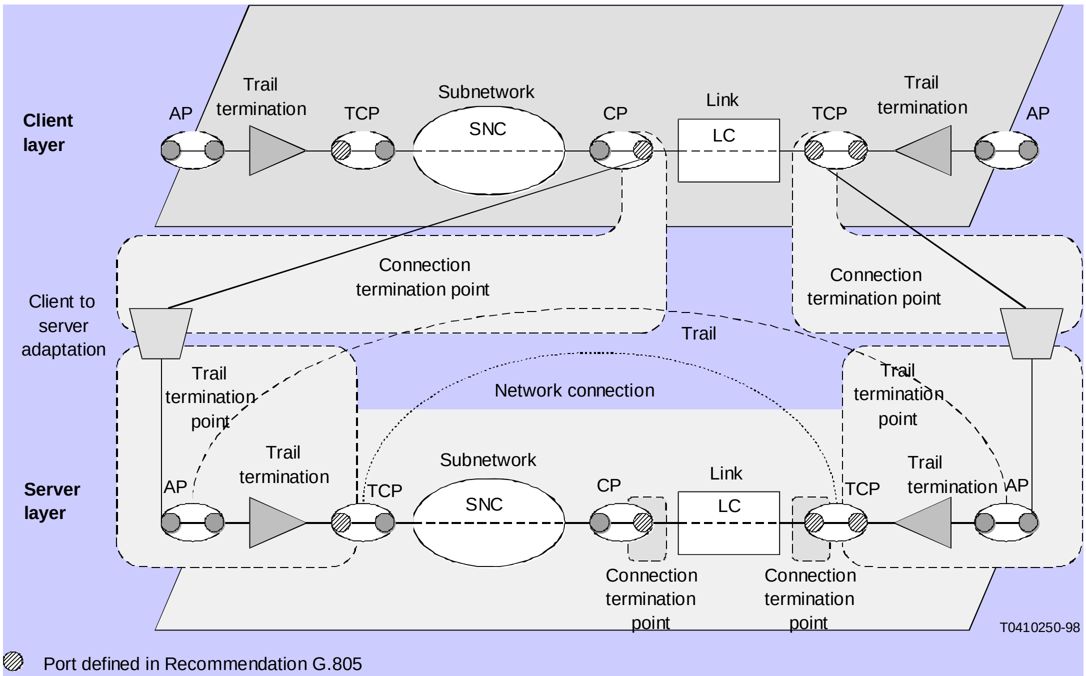


Figure 128 Transport Network Resource Model (G.852.2)

The inclusion of inverse multiplexing, adaptation and trail termination function cardinalities, and link partitioning (taken from G.852.2) are the essential enhancements of the current issue of G.805 (March 2000, published in August 2001) compared to its predecessor (November 1995).

G.805 classifies transport network layers into *service layers*, *path layers*, and *physical layers*. Physical layers are either media-independent *transmission path (TPath) layers* or media-dependent *transmission media (TMedia) layers* (= core transmission layers). TMedia layers are *section layers* (e.g., multiplex sections, regenerator sections, digital sections, optical channels) or *physical media layers* (e.g., wired cables, optical fibres, radio frequency channels).

G.805 describes the functional and structural architecture of connection-oriented networks in a generic way, i.e. independently of the underlying networking technologies. Its power is revealed when applying it to technologies of a concrete environment. The application consists of the identification of the individual layers, their characteristic information, and their adaptation and trail termination functions.

Traditional examples are *PDH layers*, *SDH layers*, *SONET layers*, *OTN layers*, and *ATM layers*. While PDH, SDH, SONET, and OTN are connection-oriented (CO) and circuit-switched (CS) technologies, ATM is CO and packet-switched (PS). Figure 129 (on page 131) provides an overview of the transmission layers of these technologies. They are already available with release 2 of the MTNM interface.

Technology pertinent standard(s)	**Layer Type**	**Layers**
Digital	Prime	DS0
PDH G.703, G.705	E-Carrier	E1, E2, E3, E4, E5
	T-Carrier	T1, T2, T3
SDH G.707, G.783, G.803	LOVC TPath	VC-11, VC-11-Xv, VC-12, VC-12-Xv, VC-2, VC-2-Xc, VC-2-Xv, VC-3, VC-3-Xv (X = 1..256)
	HOVC TPath	VC-3, VC-3-Xv, VC-4, VC-4-Xc, VC-4-Xv
	Multiplex Section	STM-n (n = 0, 1, 4, 8, 16, 64, 256)
	Regenerator Section	STM-n (n = 0, 1, 4, 8, 16, 64, 256)
SONET T1.105, GR-253	VT TPath	VT-1.5, VT-1.5-Xv, VT-2, VT-2-Xv, VT-3, VT-6, VT-6-Xc, VT-6-Xv
	STS TPath	STS-SPE, STS-Xc, STS-Xv, STS-3c-SPE, STS-3c-Xc, STS-3c-Xv
	SONET Line	STS-n, OC-n (n = 1, 3, 12, 24, 48, 192, 768)
	SONET Section	STS-n, OC-n (n = 1, 3, 12, 24, 48, 192, 768)
OTN G.709, G.798, G.872	Digital Path	OPUk, OPUk-Xv, ODUk (k = 1, 2, 3)
	Digital Section	OTUk, OTUkV (k = 1, 2, 3)
	Optical Path	OCh, OChr
	Optical Section	OMSn, OTSn, OPSn (n >= 0)
ATM I.150, I.326, I.731, I.732	Path	VC, VP
	TPath	UNI, NNI, layering depending on underlying transport technology

Figure 129 Traditional Transmission Technologies

Refer to the supporting document SD1-17_LayerRates.pdf for an overview of these and more transmission layers and technologies supported by the current release of the MTNM interface.

Revision History

Version	Date	Description of Change
3.0	April 2005	
3.0	June 2005	References updated
3.1	December 2005	Version in names of referenced supporting documents deleted.
3.2	January 2007	Minor enhancements to account for Control Plane and Ethernet additions in MTNM 3.5 (referencing additional supporting documents). Minor enhancements to improve wordings in the context of MTOSI.

Acknowledgements

<FirstName>	<LastName>	<Company>
		All members of the mTOP team have provided input to this document via comments and contributions.

How to comment on the document

Comments and requests for information must be in written form and addressed to the contact identified below:

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Please be specific, since your comments will be dealt with by the team evaluating numerous inputs and trying to produce a single text. Thus we appreciate significant specific input. We are looking for more input than wordsmith" items, however editing and structural help are greatly appreciated where better clarity is the result.

