Internet Engineering Task Force
Internet-Draft
Intended status: Informational
Expires: January 2, 2012

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July 1, 2011

A framework for Management and Control of optical interfaces supporting G.698.2

draft-kunze-g-698-2-management-control-framework-00

Abstract

This document provides a framework that describes a solution space for the control and management of optical interfaces according to the Black Link approach as specified by ITU-T [ITU.G698.2] and further revisions. In particular, it examines topological elements and related network management measures.

Optical Routing and Wavelength assignment based on WSON is out of scope. This document concentrates on the management of optical interfaces. The application of a dynamic control plane, e.g. for auto-discovery or for the distribtion of interface parameters, is complementary. Anyway, this work is not in conflict with WSON but leverages and supports related work already done for management plane and control plane.

The framework document will not address the client mapping into G.709. This document only addresses the lower layers. Furthermore, support for Fast Fault Detection, to e.g. trigger Protection Switching is provided by the WDM interface capability of the client interface (e.g. ITU-T G.709) is out of scope for this work. Additionally the wavelength ordering process and the process how to determine the demand for a new wavelength from A to Z is out of scope.

Status of This Memo

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Table of Contents

1. Introduction

The usage of the Black Link approach in carrier long haul and aggregation networks adds a further option for operators to facilitate their networks. The integration of optical coloured interfaces into routers and other types of clients could lead to a lot of benefits regarding an efficient and optimized data transport for higher layer services.

Carriers deploy their networks today as a combination of transport and packet infrastructure. This ensures high available and flexible data transport. Both network technologies are managed usually by different operational units using different management concepts. This is the status quo in many carrier networks today. In the case of a black link deployment, where the coloured interface moves into the client (e.g. router), it is necessary to establish a management connection between the client providing the coloured interface and the corresponding EMS (Element Management System) of the transport network to ensure that the coloured interface parameters can be managed in the same way as traditional deployments allow this.

The objective of this document is to provide a framework that describes the solution space for the control and management of WDM Black Links as specified by ITU-T [ITU.G698.2] and further revisions. In particular, it examines topological elements and related network management measures.

Optical Routing and Wavelength assignment based on WSON is out of scope. This document concentrates on the management of optical interfaces. The application of a dynamic control plane, e.g. for auto-discovery or distribute interface parameters, is complementary. Anyway, this work is not in conflict with WSON but leverages and supports related work already done for management plane and control plane.

Furthermore, support for Fast Fault Detection, to e.g. trigger Protection Switching is provided by the WDM interface capability of the client interface (e.g. ITU-T G.709) is out of scope for this work. Additionally the wavelength ordering process and the process how to determine the demand for a new wavelength from A to Z is out of scope.

Note that Control and Management Plane are two separate entities that are handling the same information in different ways. This document covers management as well as control plane considerations in different management cases of colored interfaces.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. Terminology and Definitions

Black Link: The Black Link [ITU.G698.2] allows supporting an optical transmitter/receiver pair of one or different vendors to inject a DWDM channel and run it over an optical network composed of amplifiers, filters, add-drop multiplexers from a different vendor. Therefore the standard defines the ingress and egress parameters at the interface Ss and Rs.

Coloured Interface: The term coloured interface defines the single channel optical interface that is used to bridge long distances and is directly connected with a DWDM system. Coloured interfaces operate on a fix wavelength or within a wavelength band (tunability). Coloured interface is a more generic term and it is a superset of the Black Link.

Friendly Wavelength: A friendly wavelength is a wavelength that is generated or originated by an optical interface that is not part of the WDM system but completely managed and known by the WDM system.

Alien Wavelength: Alien Wavelength: An alien wavelength is a wavelength that is generated or originated by an optical interface that is not part of the WDM system and not managed and known by the WDM system.

Forward error correction (FEC): FEC is an important way of improving the performance of high-capacity long haul optical transmission systems. Employing FEC in optical transmission systems yields system designs that can accept relatively large BER (much more than 10-12) in the optical transmission line (before decoding).

Intra-domain Interface (IaDI): The intra-domain interface (line site of the optical system) is a physical interface within an optical administrative or vendor domain and is implemented as:

a. standardized single channel interface specified according to G.698.2 (standardized optical interface AND OTUk according G.709) or

b. proprietary single channel interface proprietary optical interface OR functionally specified OTUkV according G.709, i.e. proprietary FEC.

Inter-Domain Interface(IrDI): The inter-domain interface is a physical interface that represents the boundary between two administrative domains as well as the boundary between client and optical domain.

Management Plane: Management Plane: The management plane supports FCAPS (Fault, Configuration, Accounting, Performance and Security Management) capabilities for carrier networks.

Control Plane: The control plane supports signalling, path computation, routing, path setup and restoration.

Client Network Layer: The client network layer is the layer above (on top) the WDM layer, from the perspective of the WDM layer.

Transponder: A Transponder is a network element that performs O/E/O (Optical /Electrical/Optical) conversion. In this document it is referred only transponders with 3R (rather than 2R or 1R regeneration) as defined in [ITU.G.872]

3. DWDM Black Link Management Solution Space

Basically the management of optical interfaces using a Black Link deals with aspects needed for setup, tear down and maintenance of wavelengths and all related optical parameters, which are demanded by a client network layer (the layer above WDM). The following types of WDM networks are considered for a management of optical interfaces using a black link:

a. Passive WDM

b. Legacy point to point WDM systems

c. Legacy WDM systems with OADMs

d. Transparent optical networks supporting specific IPoDWDM functions, interfaces or protocols

Table 1 provides a list of tasks, which are related to BL management, It is indicated which domain (optical or client) is responsible for a task. The relevance of a task for each type of WDM network is also indicated.

Task	Domain	a	b	c	d
determination of centre frequency	client	R	R	R	R
configuration of centre frequency at colored IF	optical	NR	NR	R	R
path computation of wavelength	optical	NR	NR	R	R
routing of wavelength	optical	NR	NR	R	R
wavelength setup across optical network	client	?	?	R	R
detection of wavelength fault	optical	R	R	R	R
fault isolation, identification of root failure	optical	NR	R	R	R
repair actions within optical network	optical	R	R	R	R
protection switching of wavelength	optical	NR	NR	R	R
restoration of wavelength	optical	NR	NR	R	R

Table 1: List of tasks related to BL management

Furthermore the following deployment cases will be considered:

a. Exclusive Black Link deployment

b. Black Link deplyoment in combination with grey client network interfaces

Case b) is motivated by the usage of legacy equipment using the traditional connection as described in Figure 1 combined with the BL approach.

3.1. Description of Client Network Layer - WDM connection

3.1.1. Traditional WDM deployments

The ordinary connection of a client layer network towards a WDM system is based today on client interfaces (grey) bridging short or intermediate distances between client and WDM system. The Optical Signal incoming into the WDM system must be converted (OEO conversion) to corresponding WDM wavelength grid and the power level that is applicable for the WDM transmission path. This conversion is done by a component termed as transponder (see Figure 1).

After that OEO conversion the signal complies with the parameters that are specified for a certain WDM link.

Figure 1 shows the traditional Client - WDM interconnection using transponders for wavelength conversion. IrDI and IaDI as defined in Section 2 specifying the different demarcation areas related to external and internal connections

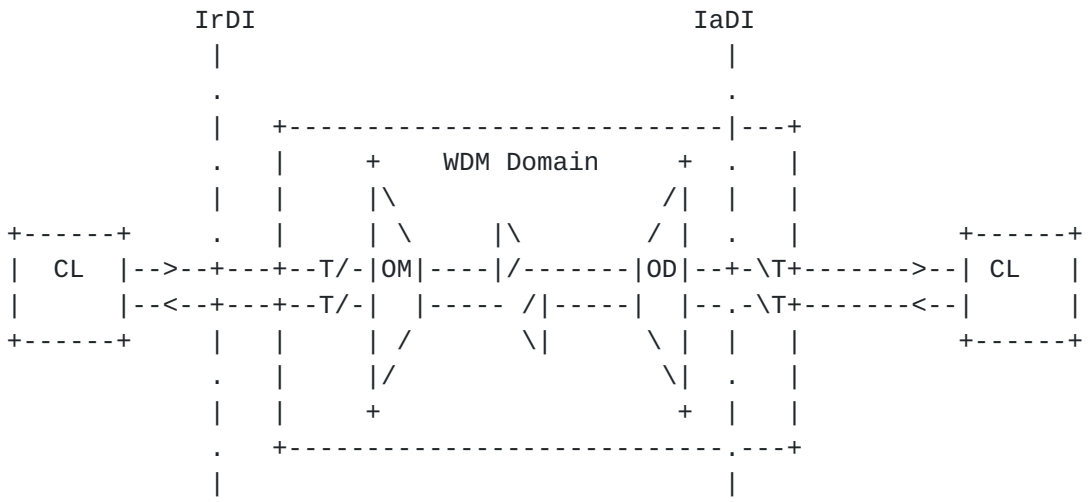


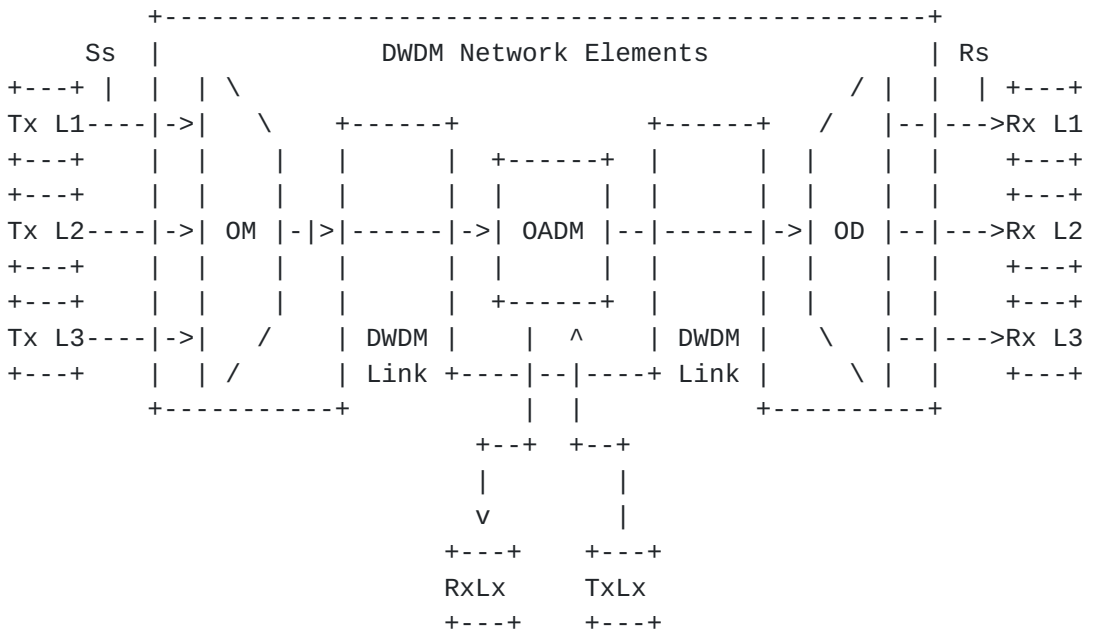
Figure 1: Inter and Intra-Domain Interface Identification

The management and control of WDM and client layer is done by different control and management solutions. Different operational units are responsible for client and WDM layer.

3.1.2. Black Link Deployments

In case of a black link deployment Figure 2 the DWDM transceiver is located directly at the client and the grey interfaces will be saved. In that case a solution must be found to manage that coloured interface in the same way as in the traditional case. This requirement must be fulfilled especially in the cases where legacy equipment and Black Link Wavelength interfaces will be used in parallel or together and the operational situation is unchanged.

Figure 2 shows a set of reference points, for the linear "black-link" approach, for single-channel connection (Ss and Rs) between transmitters (Tx) and receivers (Rx). Here the WDM network elements include an OM and an OD (which are used as a pair with the opposing element), one or more optical amplifiers and may also include one or more OADMs.



Ss = reference point at the DWDM network element tributary output
Rs = reference point at the DWDM network element tributary input
Lx = Lambda x
OM = Optical Mux
OD = Optical Demux
OADM = Optical Add Drop Mux

from Fig. 5.1/G.698.2

Figure 2: Linear Black Link

Independent from the WDM networks that are considered the usage of colored interfaces must perform as well in mixed setups with both legacy and colored interface equipment using the BL.

4. Black Link Operation scenarios

A Comparison of the black link with the traditional operation scenarios provides an insight of similarities and distinctions in operation and management. The following four use cases provide an overview about operation and maintenance processes.

4.1. Bringing into service

tbd.

4.2. Configuration Management

tbd.

4.3. In service (performance management)

tbd.

4.4. Fault Clearance

tbd.

5. Black Link Control and Management Solutions

Operation and management of WDM systems is traditionally seen as a homogenous group of tasks that could be carried out best when a single management system or an umbrella management system is used. Each WDM vendor provides a management system that also administrates the wavelengths.

This old operational approach was predicted on a high amount/rate of connection oriented traffic in carrier networks. This behaviour has been changed completely. Today IP is the dominating traffic in the network and from the operating perspective it is more beneficial to use a common management and operation approach. Due to a long history of operational separation it must be possible to manage and operate Black Link deployments with the traditional approach too.

Therefore from the operational point of view in a pure Black Link or in a mixed setup with legacy equipment (transponders) there are two approaches to manage and operate the network.

1. Separate operation and management of client and Transport network

    a. Direct link to the management system (e.g. EMS, OSS)

    b. Indirect link to the management system; using a protocol

between the peer node and the directly connected WDM system node to exchange management information

2. Common operation and management of IP and Transport network

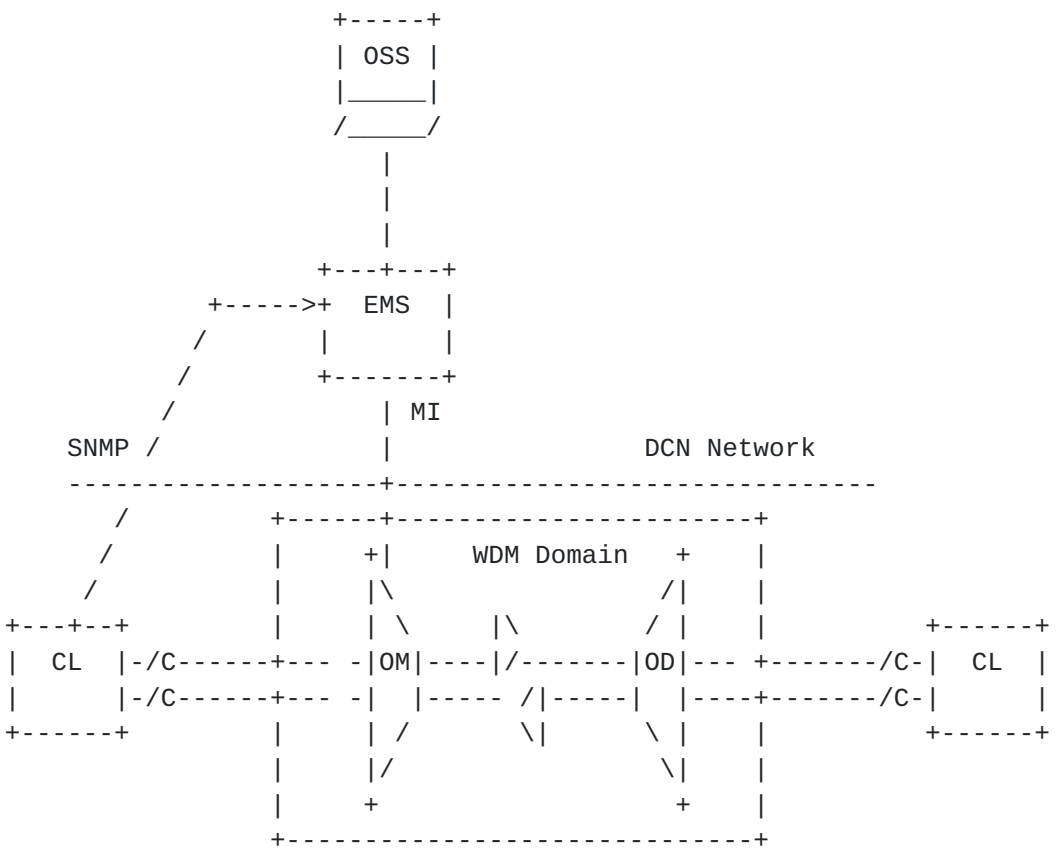
The first option keeps the status quo in large carrier networks as mentioned above. In that case it must be ensured that the full FCAPS Management (Fault, Configuration, Accounting, Performance and Security) capabilities are supported. This means from the management staff point of view nothing changes. The transceiver/receiver optical interface will be part of the optical management domain and will be managed from the transport management staff.

The second option should be favoured if the underlying WDM transport network is mainly used to interconnect IP nodes and the service creation and restoration will be done on higher layers (e.g. IP/MPLS). Then it is more beneficial have a higher level of integration and a common management will be more efficient.

5.1. BL Separate Operation and Management Approaches

5.1.1. Direct connection to the management system

As depicted in Figure 3 one possibility to manage the optical interface within the client is a direct connection to the management system of the optical domain. This ensures manageability as usual.



CL = Client
/C = Coloured Interface
OM = Optical Mux
OD = Optical Demux
EMS = Element Management System
MI= Management Interface

Figure 3: Connecting BL on Transport Management

The exchange of management information between client and management system assumes that some form of a direct link exists between the client node and the WDM management system (e.g. EMS). This may be an Ethernet Link or a DCN connection.

It must be ensured that the optical interface can be managed in a standardized way to enable interoperable solutions between different optical interface vendors and vendors of the optical network management software. RFC 3591 [RFC3591] defines manage objects for the optical interface type but does not cover the scenarios described by this framework document. Therefore an extension to this MIB for the optical interface has been drafted in [Black-Link-MIB]. In that case SNMP is used to exchange data between client and management system of the WDM domain.

Note that a software update of the interface components of the client does not lead obligatory to an update of the software of the EMS and vice versa.

5.1.2. Indirect connection to the WDM management system

The alternative as shown in Figure 4 can be used in cases where a more automated relationship between transport node and router is aspired. In that case a combination of rudimentary control plane features and manual management will be used. It is a first step into a more control plane oriented operation model.

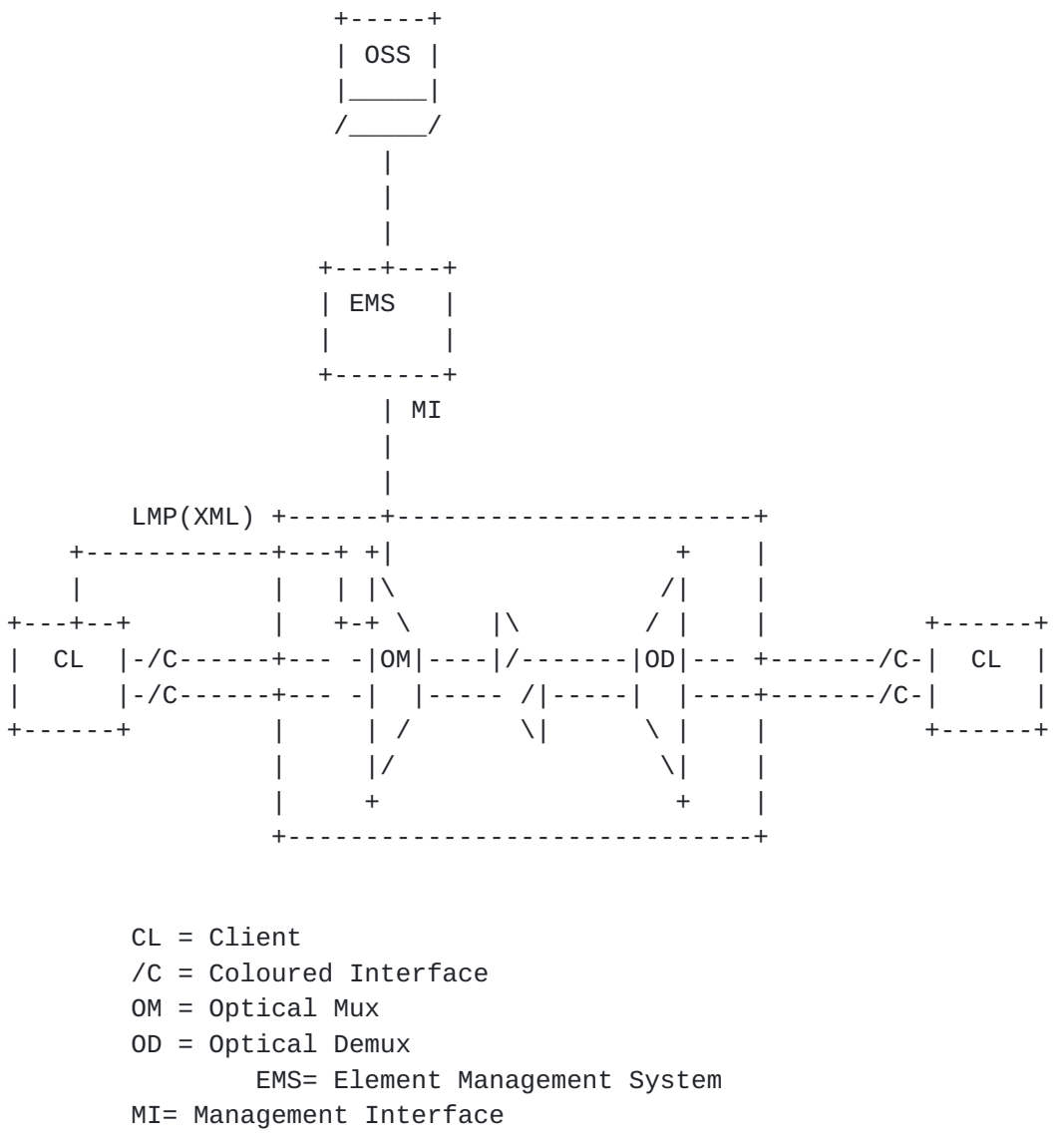


Figure 4: Direct connection between peer node and first optical network node

For information exchange between client and the direct connected node of the optical transport network LMP as specified in RFC 4209

[RFC4209] can (should) be used. This extension of LMP may be used between a peer node and an adjacent optical network node as depicted in Figure 4.

Recently LMP based on RFC 4209 does not support the transmission of configuration data (information). This functionality has to be added to the existing extensions of the protocol. The use LMP-WDM assumes that some form of a control channel exists between the client node and the WDM equipment. This may be a dedicated lambda, an Ethernet Link, or a DCN. It is proposed to use an out of band signalling over a separate link or DCN to ensure a high availability.

5.2. Control Plane Considerations

Basically it is not mandatory necessary to run a control plane in Black Link scenarios at least not in simple black link case where clients will be connected point to point using a simple WDM infrastructure (multiplexer and amplifier). As a first step it is possible to configure the entire link using the standard management system and a direct connection of the router or client to the EMS of the transport network. Configuration information will be exchanged using SNMP (see sections Section 5.1.1).

Looking at the control plane the following two scenarios may be considered:

a. A common control plane for transport and client network; this implies a single operation unit responsible for both client and transport network management.

b. A separate control plane for client and optical network without any interaction

As mentioned in chapter Section 5.1.2 some control plane features like LMP in an enhanced version could be used.

In such simple scenario it is imaginable to use only LMP to exchange information between the nodes of the optical domain. LMP must be run between the both end-points of the link and between the edge node and the first optical network node.

5.2.1. Black Link deployment with common control plane

tbd.

5.2.2. Black Link deployment with an separate control plane

tbd.

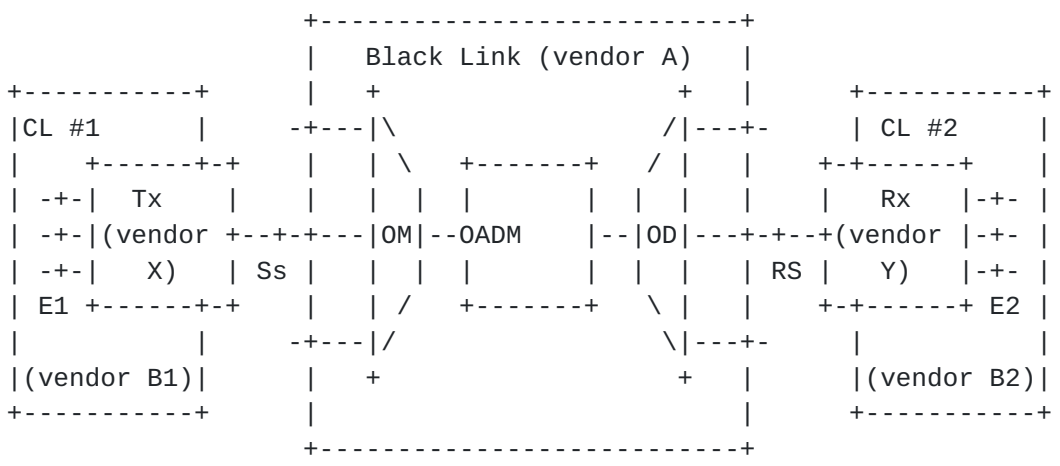
6. Requirements for BL and FW deployments

This section raises requirements from the carrier perspective and will be removed in a separate requirements draft if necessary.

6.1. Interoperability Aspects

For carrier network deployments, interoperability is a key requirement. Today it is state-of-the-art to interconnect e.g. clients from different vendors and a WDM transport system using short-reach, grey interfaces. Applying the Black Link (BL) concept, clients (e.g. routers) now become directly connected via transport interfaces which must be interoperable to each other.

A progessive approach addressing interoperability is shown in Figure 5.According to the concept of ITU-T G.698.2 the black link, the single channel (coloured) Tx and the Rx can be provided by three different vendors, namely vendor A (black link designer), and vendors X and Y for the Tx/Rx. The single-channel reference points Ss and Rs indicate the demarcation between the Tx/Rx and the black link, and the set of optical parameters refers to these reference points according to G.698.2. However, G.698.2 does not give any insight into the client equipment (CL), e.g. routers or switches, containing the optical transmitters and receivers. The electrical interfaces of the Tx/Rx are indicated by E1/E2. The client equipment CL #1 containing the Tx is provided by a vendor B1 who is not necessarily the same vendor as the vendor X of the Tx. Multi-source agreements (MSA) for pluggable modules (e.g. for SFPs, XFPs, etc.) specify form factors and electrical interfaces thus enabling in principle to use a pluggable transmitter from any vendor who complies with the MSA. Similarly, the client equipment at the receiver side can be provided by a vendor B2 different from the vendor Y of the pluggable receiver. This modularity feature, i.e. the capability to use in principle different vendors for the client equipment, modular (pluggable) transmitters/receivers, and the black link is a key requirement addressing interoperability issues of the black link approach



CL = Client
/C = Coloured Interface
OM = Optical Mux
OD = Optical Demux
EMS= Element Management System
MI= Management Interface

Figure 5: Interoperability aspects

In practice, a network operator may not use five different vendors when implementing black link systems. A simplified use case could be to choose the same vendor B for the client equipment on both sides (i.e. vendor B1 = vendor B2 = vendor B) and to choose the same vendor X for the Tx and Rx (i.e. vendor X = vendor Y) thus enabling to use universal pluggable modules for the optical transmitters and receivers.

An even more simplified use case could be to choose the same vendor B for all client equipment and Tx/Rx (i.e. B = B1 = X = B2 = Y) thus having only two vendors for the whole set-up, namely vendor A and vendor B, but to give up the possibility to use universal pluggable modules.

Other vendor combinations could also be realized (e.g. vendor X = vendor Y = vendor A).

7. Acknowledgements

The author would like to thank Ulrich Drafz for the very good teamwork during the last years and the initial thoughts related to the packet optical integration. Furthermore the author would like to thank all people involved within Deutsche Telekom for the support and

fruitful discussions.

8. IANA Considerations

This memo includes no request to IANA.

9. Security Considerations

This document has no requirement for a change to the security models within GMPLS, associated protocols and management interfaces. As well as the LMP security models could be operated unchanged.

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