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**Applicability of Abstraction and Control of Traffic Engineered
Networks (ACTN) to Packet Optical Integration (POI)**

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Abstract

This document considers the applicability of ACTN to Packet Optical Integration (POI) and IP and Optical DWDM domain internetworking, and specifically the YANG models being defined by the IETF to support this deployment architecture.

In this document we highlight the IETF protocols and data models that may be used for the ACTN and control of POI networks, with particular focus on the interfaces between the MDSC (Multi-Domain Service Coordinator) and the underlying Packet and Optical Domain Controllers (P-PNC and O-PNC) to support Packet Optical Integration (POI) use cases.

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[1. Introduction](#)

This document aims to collect information about the level of protocols and data models standardization implementations of ACTN architecture, with particular focus on the interfaces between the MDSC (Multi-Domain Service Coordinator) and underlying Packet and Optical Domain Controllers (P-PNC and O-PNC), for Packet Optical Integration (POI).

Understanding the level of standardization and the gaps will help to better assess the feasibility of integration between IP and Optical DWDM domain, in an end-to-end multi-vendor service provisioning perspective.

In this document, key use cases will be described, and for each use case according to the ACTN architecture shown in Figure 1, the scope will address the interactions with both the IP and optical domains.

For both domains, information on functions, protocols and data models, available on each use case, must be reported.

[2. Reference Scenario](#)

This document is considering a network scenario with multiple Optical domains and multiple Packet domains.

Figure 1 shows this scenario in case of two Optical domains and two Packet domains:

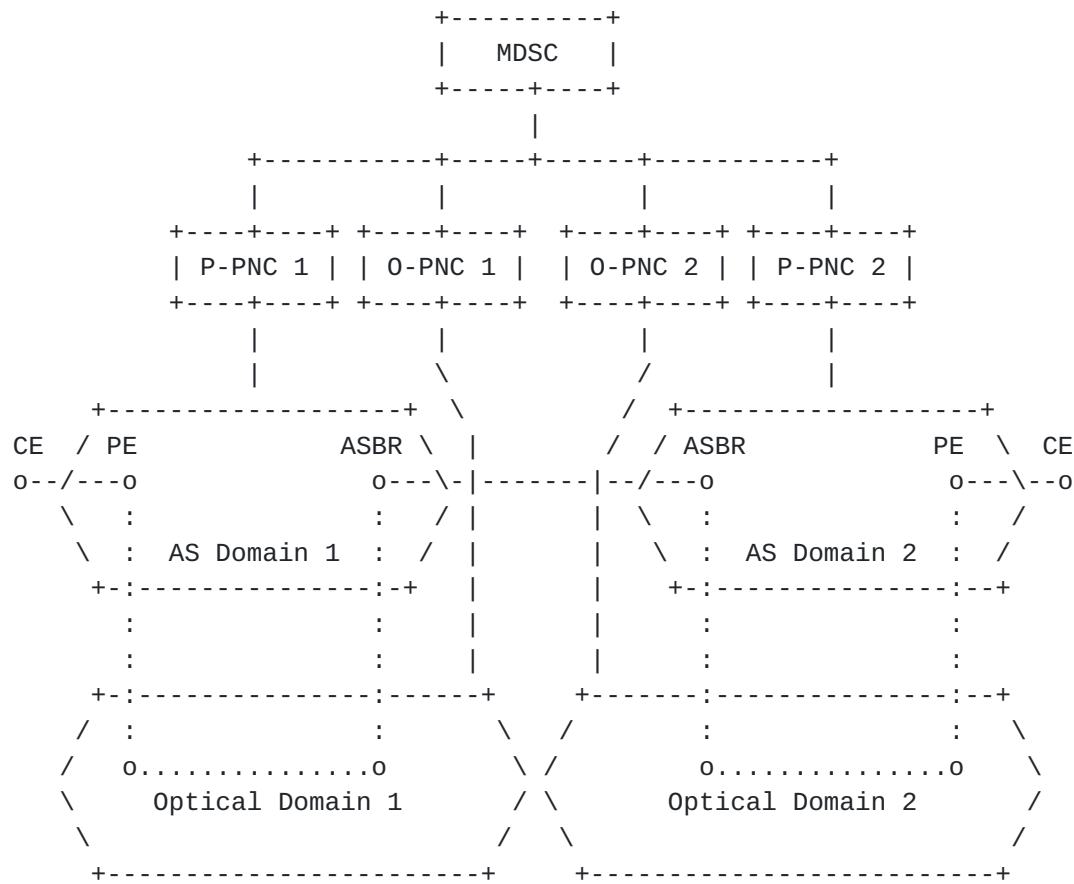


Figure 1 - Reference Scenario

The ACTN architecture, defined in [RFC8453], is used to control this multi-domain network where each P-PNC is responsible for controlling its IP domain (AS), and each O-PNC is responsible for controlling its Optical Domain. The MDSC is responsible for coordinating the whole multi-domain multi-layer (Packet and Optical) network. A specific standard interface (MPI) permits MDSC to interact with the different Provisioning Network Controller (O/P-PNCs). The MPI interface presents an abstracted topology to MDSC hiding technology-specific aspects of the network and hiding topology details depending on the policy chosen regarding the level of abstraction supported. The level of abstraction can be obtained based on P-PNC and O-PNC configuration parameters (e.g. provide the potential connectivity between any PE and any ASBR in an MPLS-TE network).

In this scenario it is assumed that:

- o The domain boundaries between the IP and Optical domains are congruent. In other words, one Optical domain supports connectivity between Routers in one and only one Packet Domain.
- o Inter-domain links exist only between Packet domains (i.e., between ASBR routers) and between Packet and Optical domains (i.e., between routers and ROADMs). In other words, there are no inter-domain links between Optical domains
- o The interfaces between the routers and the ROADM's are "Ethernet" physical interfaces
- o The interfaces between the ASBR routers are "Ethernet" physical interfaces

2.1. Generic Assumptions

This section describes general assumptions which are applicable at all the MPI interfaces, between each PNC (Optical or Packet) and the MDSC, and also to all the scenarios discussed in this document.

The data models used on these interfaces are assumed to use the YANG 1.1 Data Modeling Language, as defined in [[RFC7950](#)].

The RESTCONF protocol, as defined in [[RFC8040](#)], using the JSON representation, defined in [[RFC7951](#)], is assumed to be used at these interfaces.

As required in [[RFC8040](#)], the "ietf-yang-library" YANG module defined in [[RFC8525](#)] is used to allow the MDSC to discover the set of YANG modules supported by each PNC at its MPI.

3. Scenario 1 - Topology discovery, network inventory and multilayer correlation

In this scenario, the MDSC needs to discover the network topology, at both WDM and IP layers, in terms of nodes (NEs) and links, including inter-domain links.

Each PNC provides to the MDSC an abstract topology view of the WDM or of the IP topology of the domain it controls. This topology is abstract in the sense that some detailed NE information is hidden at the MPI, but all the NEs and physical links are exposed as abstract nodes and links within the abstract topology.

The MDSC also keeps an up-to-date network inventory of both IP and WDM layers and correlates such information (e.g., which port, lambda, and the direction being used by a specific IP service on the WDM equipment).

3.1. Common YANG models used at the MPIs

Both Optical and Packet PNCs use the following common topology YANG models at the MPI to report their abstract topologies:

- o The Base Network Model, defined in the "ietf-network" YANG module of [[RFC8345](#)]
- o The Base Network Topology Model, defined in the "ietf-network-topology" YANG module of [[RFC8345](#)], which augments the Base Network Model
- o The TE Topology Model, defined in the "ietf-te-topology" YANG module of [[TE-TOPO](#)], which augments the Base Network Topology Model

These common YANG models are generic and augmented by technology-specific YANG modules as described in the following sections.

3.1.1. YANG models used at the Optical MPIs

The Optical PNC also uses at least the following technology-specific topology YANG models, providing WDM and Ethernet technology-specific augmentations of the generic TE Topology Model:

- o The WSON Topology Model, defined in the "ietf-wson-topology" YANG modules of [[WSON-TOPO](#)], or the Flexi-grid Topology Model, defined in the "ietf-flexi-grid-topology" YANG module of [[Flexi-TOPO](#)].
- o The Ethernet Topology Model, defined in the "ietf-eth-te-topology" YANG module of [[CLIENT-TOPO](#)]

The WSON Topology Model or, alternatively, the Flexi-grid Topology model is used to report the DWDM network topology (e.g., ROADMs and links) depending on whether the DWDM optical network is based on fixed grid or flexible-grid.

The Ethernet Topology is used to report the access links between the IP routers and the edge ROADMs.

3.1.2. Required YANG models at the Packet MPIs

The Packet PNC also uses at least the following technology-specific topology YANG models, providing IP and Ethernet technology-specific augmentations of the generic Topology Models:

- o The L3 Topology Model, defined in the "ietf-l3-unicast-topology" YANG modules of [[RFC8346](#)], which augments the Base Network Topology Model
- o The Ethernet Topology Model, defined in the "ietf-eth-te-topology" YANG module of [[CLIENT-TOPO](#)], which augments the TE Topology Model

The Ethernet Topology Model is used to report the access links between the IP routers and the edge ROADMs as well as the inter-domain links between ASBRs, while the L3 Topology Model is used to report the IP network topology (e.g., IP routers and links).

3.2. Inter-domain link Discovery

In the reference network of Figure 1, there are two types of inter-domain links:

- o Links between two IP domains (ASes)
- o Links between an IP router and a ROADM

Both types of links are Ethernet physical links.

The inter-domain link information is reported to the MDSC by the two adjacent PNCs, controlling the two ends of the inter-domain link.

The MDSC can understand how to merge these inter-domain links together using the plug-id attribute defined in the TE Topology Model [[TE-TOPO](#)], as described in as described in [section 4.3](#) of [TE-TOPO].

A more detailed description of how the plug-id can be used to discover inter-domain link is also provided in section 5.1.4 of [[TNBI](#)].

Both types of inter-domain links are discovered using the plug-id attributes reported in the Ethernet Topologies exposed by the two adjacent PNCs. The MDSC can also discover an inter-domain IP link/adjacency between the two IP LTPs, reported in the IP

Topologies exposed by the two adjacent P-PNCs, supported by the two ETH LTPs of an Ethernet Link discovered between these two P-PNCs.

Two options are possible to discover these inter-domain links:

1. Static configuration
2. LLDP [IEEE 802.1AB] automatic discovery

Since the static configuration requires an administrative burden to configure network-wide unique identifiers, the automatic discovery solution based on LLDP is preferable when LLDP is supported.

As outlined in [TNBI], the encoding of the plug-id namespace as well as of the LLDP information within the plug-id value is implementation specific and needs to be consistent across all the PNCs.

4. Scenario 2 - Provisioning of an IP Link over DWDM

In this scenario, the MSDC needs to coordinate the creation of an IP link, or a LAG, between two routers through a DWDM network.

It is assumed that the MDSC has already discovered the whole network topology as described in [section 3](#).

4.1. YANG models used at the MPIs

4.1.1. YANG models used at the Optical MPIs

The Optical PNC uses at least the following YANG models:

- o The TE Tunnel Model, defined in the "ietf-te" YANG module of [\[TE-TUNNEL\]](#)
- o The WSON Tunnel Model, defined in the "ietf-wson-tunnel" YANG modules of [\[WSON-TUNNEL\]](#), or the Flexi-grid Media Channel Model, defined in the "ietf-flexi-grid-media-channel" YANG module of [\[Flexi-MC\]](#)
- o The Ethernet Client Signal Model, defined in the "ietf-eth-tran-service" YANG module of [\[CLIENT-SIGNAL\]](#)

The TE Tunnel model is generic and augmented by technology-specific models such as the WSON Tunnel Model and the Flexi-grid Media Channel Model.

The WSON Tunnel Model or, alternatively, the Flexi-grid Media Channel Model are used to setup connectivity within the DWDM network depending on whether the DWDM optical network is based on fixed grid or flexible-grid.

The Ethernet Client Signal Model is used to configure the steering of the Ethernet client traffic between Ethernet access links and TE Tunnels, which in this case could be either WSON Tunnels or Flexi-Grid Media Channels. This model is generic and applies to any technology-specific TE Tunnel: technology-specific attributes are provided by the technology-specific models which augment the generic TE-Tunnel Model.

4.1.2. Required YANG models at the Packet MPIs

The Packet PNC uses at least the following topology YANG models:

- o The Base Network Model, defined in the "ietf-network" YANG module of [\[RFC8345\]](#) (see [section 3.1](#))
- o The Base Network Topology Model, defined in the "ietf-network-topology" YANG module of [\[RFC8345\]](#) (see [section 3.1](#))
- o The L3 Topology Model, defined in the "ietf-l3-unicast-topology" YANG modules of [\[RFC8346\]](#) (see [section 3.1.1](#))

If, as discussed in [section 4.2](#), IP Links created over DWDM can be automatically discovered by the P-PNC, the IP Topology is needed only to report these IP Links after being discovered by the P-PNC.

The IP Topology can also be used to configure the IP Links created over DWDM.

4.2. IP Link Setup Procedure

The MDSC requires the O-PNC to setup a WDM Tunnel (either a WSON Tunnel or a Flexi-grid Tunnel) within the DWDM network between the two Optical Transponders (OTs) associated with the two access links.

The Optical Transponders are reported by the O-PNC as Trail Termination Points (TTPs), defined in [\[TE-TOPO\]](#), within the WDM Topology. The association between the Ethernet access link and the WDM TTP is reported by the Inter-Layer Lock (ILL) identifiers, defined in [\[TE-TOPO\]](#), reported by the O-PNC within the Ethernet Topology and WDM Topology.

The MDSC also requires the O-PNC to steer the Ethernet client traffic between the two access Ethernet Links over the WDM Tunnel.

After the WDM Tunnel has been setup and the client traffic steering configured, the two IP routers can exchange Ethernet packets between themselves, including LLDP messages.

If LLDP [IEEE 802.1AB] is used between the two routers, the P-PNC can automatically discover the IP Link being setup by the MDSC. The IP LTPs terminating this IP Link are supported by the ETH LTPs terminating the two access links.

Otherwise, the MDSC needs to require the P-PNC to configure an IP Link between the two routers: the MDSC also configures the two ETH LTPs which support the two IP LTPs terminating this IP Link.

5. Security Considerations

Several security considerations have been identified and will be discussed in future versions of this document.

6. Operational Considerations

Telemetry data, such as the collection of lower-layer networking health and consideration of network and service performance from POI domain controllers, may be required. These requirements and capabilities will be discussed in future versions of this document.

7. IANA Considerations

This document requires no IANA actions.

8. References

8.1. Normative References

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9. Acknowledgments

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