Open XR Optics Management Requirements Whitepaper

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ABSTRACT:

In this whitepaper we investigate and summarize management interface and API requirements of different operators / users to prioritize and guide the specification work in Open XR Optics Forum on NBI and other management interfaces.

The Open XR Optics Forum
www.openxropticsforum.org

Open XR Optics Forum

The Open XR Optics Forum is the multi-source agreement (MSA) working group for XR optics, the industry's first point-to-multipoint coherent pluggable transceiver technology. The Open XR Optics Forum's mission is to foster collaboration that will advance development of XR optics-enabled products and services, accelerate adoption of intelligent coherent transceivers ,coherent point-to-multipoint network architectures, and drive standardization of networking interfaces to ensure ease of multi-vendor interoperability and an open, multi-source solution ecosystem.

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1 Introduction

1.1 Objectives

This whitepaper evaluates and summarizes management interface and API requirements of Open XR Optics Forum member companies' operators / users to prioritize and guide the specification work in Open XR Optics Forum on NBI and other management interfaces.

Expected Output

- Study providing Summary of Open XR Optics management interface and API requirements.
  - It will form the basis for detailed specifications of the Open XR APIs and specifications.
  - It will identify existing API definitions as candidates for use in Open XR Optics specifications.

Benefits to Open XR Optics

- Laying the groundworks for a multivendor operational environment and for seamless automation of Open XR Optics networks
- Ensuring open XR management requirements are reflected in API and data model definitions.

1.2 Scope

The Open XR Management Architecture [1] introduces the architecture for the management of Open XR Optics.

Figure 1 illustrates the Open XR management architecture and introduces the various management interfaces encompassed within.

This document summarizes the management API requirements for Open XR to ensure compatibility and ease of integration with the networks of Open XR Optics Forum members. In doing so it will also further clarify the roles of the different entities involved in Open XR Optics management, such as hosts, modules, as well as the Open XR Optics Controller.

A main goal of Open XR remains close alignment with the standards ecosystem to ensure that the Open XR management architecture seamlessly interacts with today's management environments and Open XR requirements are introduced to and met by other industry activities.

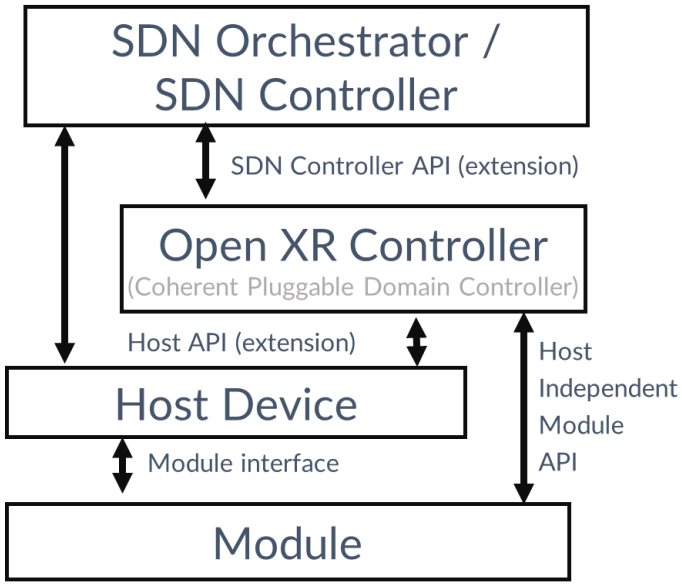

Figure 1: Open XR management architecture

In this whitepaper we:

- collect and compile requirements from the Open XR Optics Forum membership for the following API & data/information model definitions:
  - SDN controller API
  - Host API
  - Host independent module API
  - Module interface
- It will identify existing open API definitions to be used as a basis for the definition of the individual APIs in subsequent specifications.
- Identify open issues in existing API definitions related to XR control.
- Propose activities and collaboration with standards ecosystem to close open issues and extend existing open API definitions to support the use-cases defined in Open XR Optics forum.

1.3 Approach

Timeline

- Collection of requirements in Q4 23 , requirements presentations Q1 24
- Identification of API candidates and potential industry collaboration in Q2 24
- Kick off resulting workstreams for specific API definitions in Q3 24
- Publish in Q3 24

2 Requirements collection

2.1 Questionnaire

The following questions were provided to Open XR Optics Forum members (for some of the questions there may be a short term, pragmatic answer and a long-term objective which may be different.)

1. Which API(s) are you most interested in?
    1. Host independent module API?
    2. Host Module Interface?
    3. Host API / NBI?
    4. Host telemetry API?
    5. Open XR Optics controller NBI / SDN controller API?
2. What are your requirements/expectations for this API?
3. What are key use-cases that you expect to be supported?
    1. Telemetry streaming?
    2. Circuit provisioning?
    3. Inventory Management?
    4. Alarms collection & correlation?
    5. Topology reporting?
4. What APIs do you currently use or plan to use in your optical/DWDM control architecture? Host independent module API?
    1. Host Module Interface
    2. Host API / NBI
    3. Host telemetry streaming
    4. SDN controller API
5. What is the role that you see for the Open XR Optics controller?
    1. Are you planning to use it as an SDN control function in your architecture?
    2. What APIs do you expect and what other control entities will it interwork with?

2.2 Results

Answers were provided both as a complete formal response as well as informal responses in discussions or meetings. To maintain confidentiality, we have anonymized the answers as requested by some of the participants.

Most of the responses to the questionnaire agreed on fundamental objectives and principles:

- The respondents confirmed that Multivendor integration and decoupling host & module functionality as well as sourcing should be a key consideration.
- The objective of respondents is to ensure that there is no dependency on the vendors of IP controller or optical controller so that vendors can be changed over time if required.
- Introducing new technologies should become easier over time leveraging this approach.
- Besides that, it will be key to fit into existing operational and SW environments as well as the environment planned for the future.
- Also, the answers agreed on the importance of OpenConfig data model as well as the use cases for gRPC/gNMI and Netconf for telemetry streaming and configuration management respectively.

Besides the specific need for OpenConfig, the answers also agreed on the role of the Open APIs:

- While proprietary extensions are often accepted today, those need to be removed and fully incorporated into open API definitions over time.
- The APIs need to allow for configuration and monitoring of Open XR pluggables and constellations.
- Also, the open API definitions need to cover both the optical parameters required (Tx/Rx powers, SNR, Q Value, Pre-FEC/Post-FEC BER, etc.) besides allowing the host interface to be configured and operated (e.g. sub-interfaces definitions and bandwidths)

SDN architecture considerations included:

- One optical and one IP controller which are separate from each other. The clear demarcation of optical and IP layer operations was a common theme across several of the answers.
- A second option stated was one common controller for operational tasks, e.g. service provisioning with independent SW infrastructure for telemetry collection and alarm monitoring.

A very strict separation of IP and optical control domains does mean that there is no controller NBI such as TAPI required.

It is important to note that RAN or PON overlay use-cases may differ with respect to the SDN architecture as the input here was mainly focused on IPoDWDM P2P and P2MP use-cases.

The role of the open XR optics controller was seen quite differently, ranging from:

A clear role to provide overall control of the hub and leaf modules within a XR constellation,

to

ideally the open XR optics controller should not be required, if it is, it must be an open-source controller to ensure that there is no dependency on the vendor.

The following table summarizes answers on network as well as operational use-cases:

Table 1: Network and operational use-cases

		Network Operator 1	Network Operator 2	Network Operator 3	Network Operator 4
		Focus on P2MP	P2P & P2MP	P2P & P2MP ?	P2MP
Network use-cases	PON Overlay	No (although it is a possibility)			
	OpenRAN	Yes – Macrocell backhaul, + fronthaul in some cases	Yes, Fronthaul, Mid/Backhaul Asymmetrical = FH, small business, residential	Yes	
	IPoDWDM aggregation	Yes – 100 → 400G	Yes	Yes	
Operational use-cases	Circuit Provisioning	Yes	Yes	Yes	
	Inventory Management	Yes	Yes	Yes	
	Alarms collection & Correlation	Yes	Yes	Yes	
	Topology	Yes		Yes	
	Protection	Yes – 1+1, dual homing			
	Telemetry	Yes	Yes	Yes	Yes

Which API(s) are you most interested in?

Table 2: Relevant APIs

		Network Operator 1	Network Operator 2	Network Operator 3	Network Operator 4
		Open without proprietary extensions	Standards + extensions M2M not GUI, ACID, Open APIs		Standards as much as possible
Open XR optics architecture	Host independent module API	Yes, for demarcation between host and optical	Yes, should use standard data model, e.g. OpenConfig	Yes, for telemetry and read operations	Yes, standard data model mandatory, e.g. OpenConfig
	Module IF	Yes	Yes	Yes, for host control and write commands	Yes
	Host API/NBI	No	Yes	Yes, write commands	Yes
	SDN controller NBI	Yes	Yes	Yes	No
Industry's existing open API definitions	NetConf	Yes	Yes	Yes	Yes
	Rest	No			
	RestConf	Yes		Yes	
	gRPC/gNMI	Yes	Yes		Yes
	gNOI		Yes		Yes
	OpenConfig	Yes	Yes	Yes	Yes
	OpenROADM	No		No	
	T-API	No		Yes	

Depending on use-case, we see different views on the need for an open XR optics controller:

- Not desired, if required it needs to be vendor independent, ideally open-source SW.
- Key for Overall control of the hub and leaf modules within a XR constellation.
- Write commands have to be done from the IP/Host's SDN controller, at the same time Open XR optics controller and host independent interface is key for fast telemetry streaming.

3 Targeted network Use-cases

3.1 Overview

The following graphs summarizes the optical use-cases under evaluation by the link budgets working group in Open XR Optics Forum, see Figure 2.

The use-cases included are:

- Point-to-point or point-to-multipoint OpenRAN or Mobile Xhaul use-case
- Point-to-point business services
- Point-to-multipoint business services across a PON infrastructure ('PON overlay')
- Point-to-point and point-to-multipoint Metro aggregation network, e.g. in horseshoe configuration.

Please note that these network use-cases imply quite a different software / SDN control environment for the equipment and the pluggables deployed. Whereas a PON overlay use-case may rely on VOLTHA, OpenRAN deployments may leverage ORAN alliances management architecture. In the following sections we are going to look at the environment from the perspective of the Open XR optics forum keeping in mind that our approach needs to support different types of SDN environments.

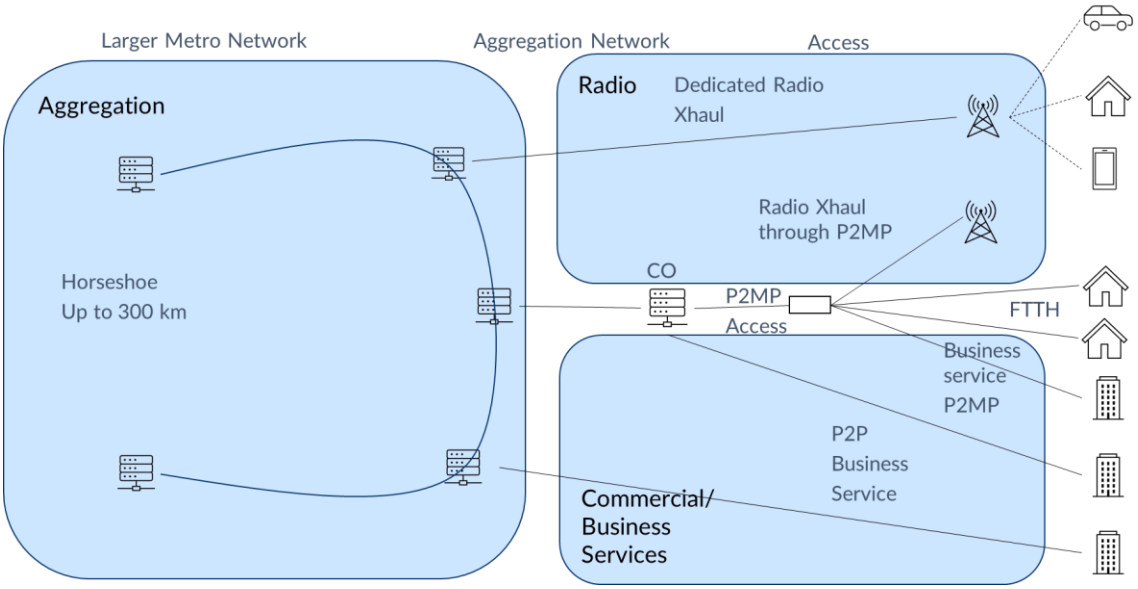

Figure 2: Network use-cases under evaluation by the link budgets working group in open XR optics forum [source: link budgets working group]

3.2 Supported Topologies

Open XR Optics does support both point-to-point as well as point-to-multipoint use-cases. It is a key objective of this whitepaper to compile management requirements covering both topologies (see Figure 3).

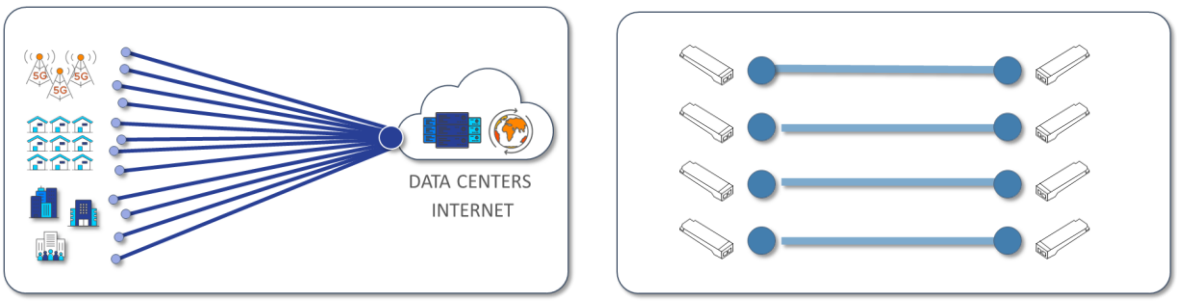

Figure 3: Point-to-multipoint and point-to-point configurations.

3.3 IPoDWDM aggregation

One common element of both point-to-point as well as point-to-multipoint use-cases described above is that open XR optics pluggable interfaces will often be deployed as pluggable interfaces in IP router equipment. It is one of the objectives of this working group to enable support of Open XR Optics pluggables in IP routers or other types of host equipment.

The one key common requirement that network operators have raised in this context is to be able to source the pluggables separately from the host equipment (see Figure 4). So, when we talk about IPoDWDM in the context of this whitepaper we refer to multi-vendor or open IPoDWDM deployment which as we shall see relies on the use of open, well-defined APIs and control interfaces.

Also decoupling of functionalities and SW versions if of high value to limit dependencies, facilitate onboarding of new vendors and technologies as well as enabling a smooth network evolution going forward.

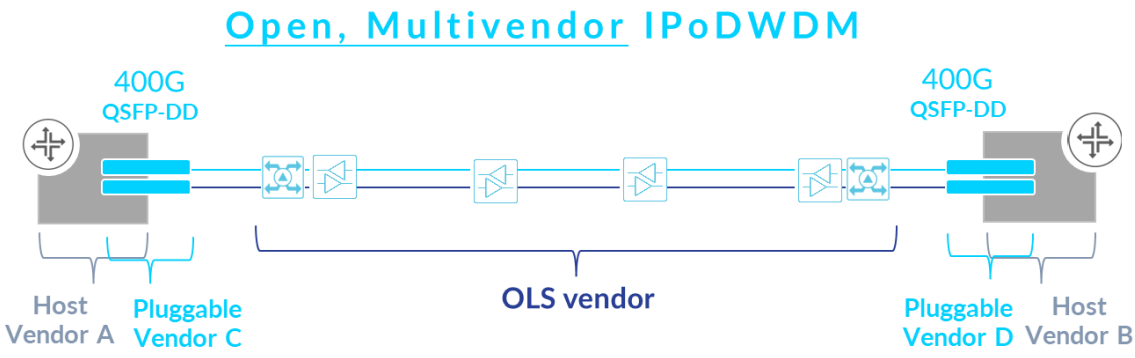

Figure 4: Open Multivendor IPoDWDM relies on independent sourcing of pluggable interfaces and thus benefits from decoupled [source: link budgets working group]

Considerations on the management of pluggables in the context of multivendor IPoDWDM networks are currently under work in several industry initiatives and standards defining organizations.

The ecosystem of APIs and Architectures is evaluated in more detail in section 7 of this document.

3.4 OpenRAN

Open RAN or Mobile Xhaul use-cases rely on deploying Open XR optics in Open RAN equipment, e.g., as defined by the ORAN alliance and shown during ORAN plugfests by Open XR Optics forum members.

In point-to-point use-cases, the control environment is expected to be very similar to the IPoDWDM deployment described previously. Options are covered in section 5 in more detail.

Point-to-multipoint networks may add an additional deployment scenario which requires the control of the smaller leaf devices through the hub node, which could potentially result in remote management of either the leaf pluggable or the whole leaf node as part of the hub's network element SW or it's network controller SW. Section 5 is going to explain these scenarios as well.

Management considerations by the open XR optics forum need to be verified against the control architecture of open RAN implementations, i.e. defined by ORAN alliance working group 9, mobile fronthaul interfaces. The options for API definitions that those organizations use for the optical network components are covered in section 7 of this whitepaper.

3.5 PON overlay

Deployment of Open XR Optics interfaces in PON overlay scenarios is included in the considerations of the link budgets working group in Open XR optics forum.

Management requirements for these use-cases, while covered by this whitepaper, may require an additional verification depending on the specific control architecture in use.

4 Operational use-cases

The requirements collected in this whitepaper result in the following list of operational use-cases are

4.1 Telemetry Streaming

Streaming of telemetry information has become an important requirement for network equipment.

The host equipment's APIs are key to support telemetry streaming, gRPC is often used for this purpose in combination with a well-defined data model for the equipment and its interfaces.

There are two key options for data models that are being discussed: First, OpenConfig covers a wide range of use-cases across network layers 0 to 3 from DWDM to IP. Second, the OpenROADM MSA focuses on the DWDM layer in OpenROADM MSA.

Due to its coverage of packet equipment's north bound API, the data model defined in OpenConfig is the main option required for the deployment of Open XR Optics interfaces.

5 Network control and management architecture considerations

5.1 Roadmap of network automation

The telecommunications industry is going through a long-term transformation of its operational environment. From a paradigm of separate operational domains for packet and optical layers with operators using a GUI or CLI to enter configuration or to monitor network status, the industry has moved towards the use of automation scripts and separate IP versus optical automation. A largely autonomous multilayer network with M2M control and a sophisticated SDN architecture remains a future vision in most of the market. This is illustrated in Figure 5.

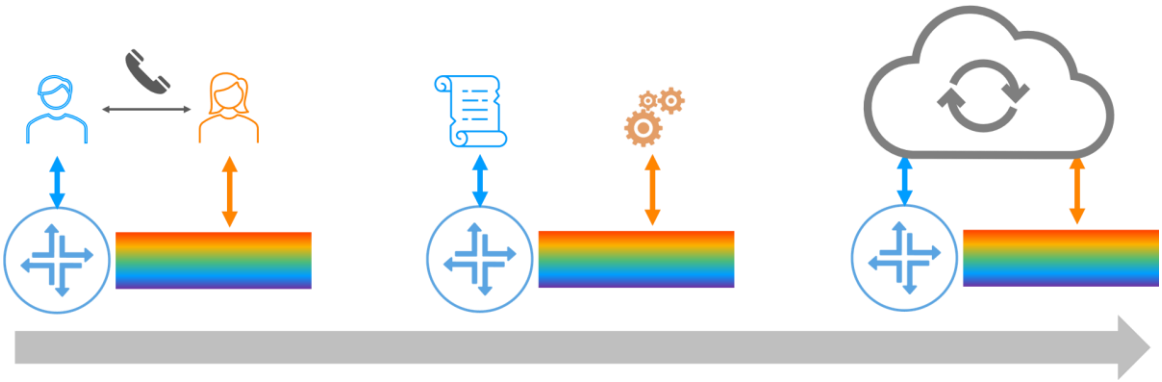

Figure 5: Evolution of network operations for the optical and IP network layers: From manual operations by separate organizations, through separate automation of the different network layers, to fully integrated network control.

5.2 Different structure of SDN control functions

The answers to the questionnaire as well as discussions in the open XR Optics forum, have shown that the operational environment differs significantly between the operators. Specifically, for XR pluggable optics integrated into routers/packet devices, we have found that the environment ranges from separate automation SW for the packet and optical domains, a single common controller across domains versus sophisticated hierarchical SDN approaches to environments where smaller (leaf) devices are managed from the head-end via the optical data connection without a true DCN being available. These different approaches are illustrated in Figure 6.

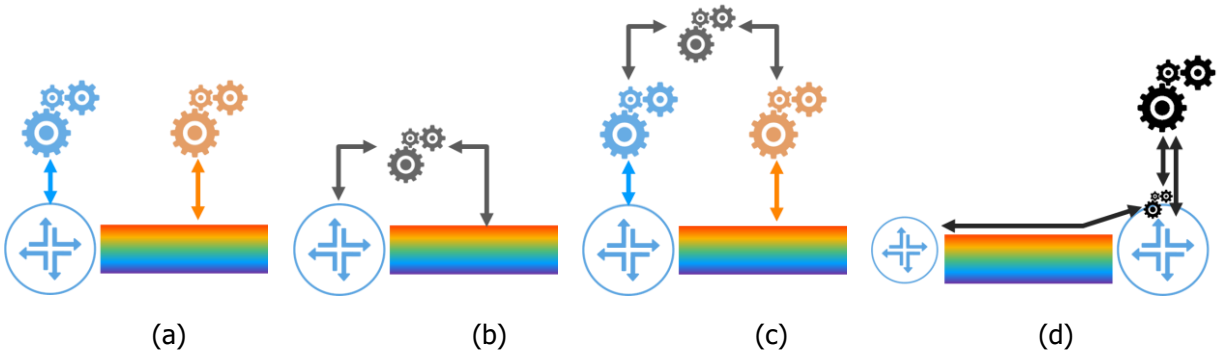

Figure 6: Point-to-multipoint and point-to-point configurations of network management systems. (a) separate network controllers managing optical and IP domains, (b) A converged controller for optical and IP domain, (c) a hierarchical SDN controller approach with separate network controllers for optical and IP domains that are managed by a SDN controller. (d) remote management of Open XR P2MP pluggable transceivers through a supervisory management channel.

5.3 Deployment scenarios

As we saw above, there are very different SDN architectures that are being used. We attribute this to fundamental differences in the deployment scenarios. In the discussion on this whitepaper, the scenarios that network operators brought up for deployment did differ quite a bit. Figure 7 illustrates 3 scenarios that really are fundamentally different and are driving significant operational differences. The first option is that a large router may host pluggable interfaces connected to multiple different DWDM line systems and sometimes even multiple domains of DWDM equipment. In other cases, the DWDM network may well be a single network domain with the packet equipment being a combination of different vendors as well as different types, even classes of equipment.

The 3rd option shows a scenario discussed quite frequently particularly in P2MP scenarios. Here, smaller devices are often not connected to a DCN but need to be managed from a larger head end device.

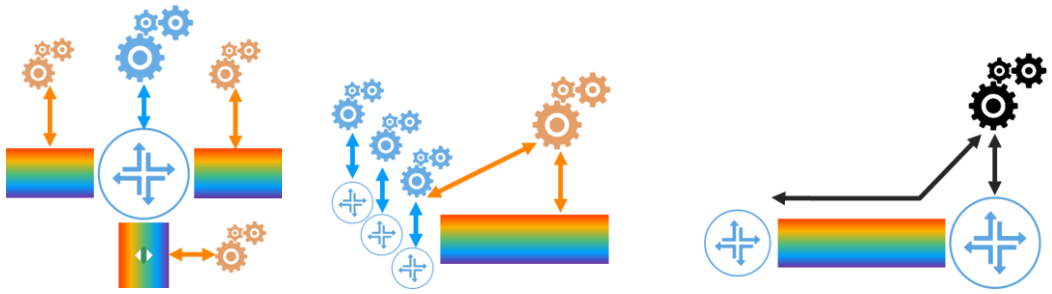

Figure 7: Point-to-multipoint and point-to-point configurations. (a) a large router may host pluggable transceivers that interface to multiple different DWDM line systems and potentially different DWDM control or vendor domains. (b) A single DWDM network that provides connectivity between different types of packet network equipment (e.g. L2, L3, Access/RAN equipment). (c) A scenario, where P2MP network infrastructure like XR Optics connects smaller remote devices that need to be managed via a larger head end device.

5.4 Different connectivity to the pluggables

The scenarios above result in different needs for connectivity from controllers to the pluggable interfaces. Figure 8 shows some of the connectivity required.

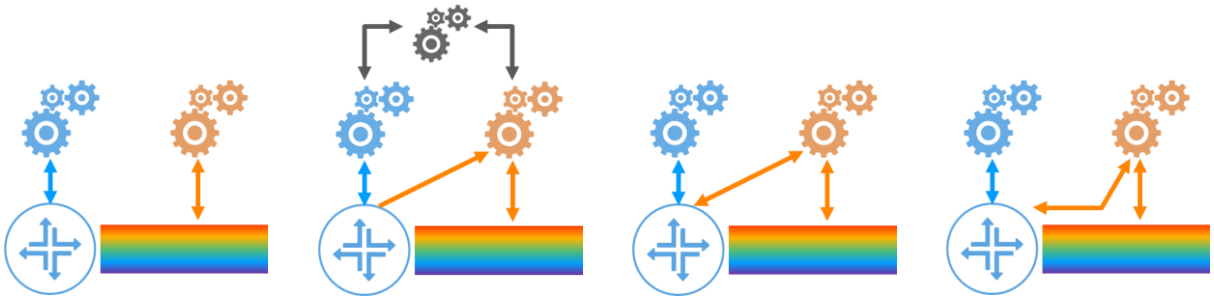

Figure 8: Point-to-multipoint and point-to-point configurations. (a) pluggables controlled by the packet network controller independently from the optical network controller, (b) a hierarchical SDN controller, where the optical domain controller controls pluggable transceivers through the host device with an option for direct read access to the host's NBI, (c) direct management of pluggable transceivers from an optical domain controller through the host's NBI, and (d) host(SW)-independent management from an optical domain controller through an in-band management channel to the optical controller.

6 Requirements

This section summarizes the API requirements for Open XR pluggable transceivers.

6.1 Host Independent Management API

XR optics enables several options to reach a pluggable transceiver directly via in-band or out-of-band communications channels. This enables host independent management of XR optics pluggable transceivers as described in [Ref Management architecture].

The requirements of the host independent API are mainly driven by the restrictions of the controller within the pluggable module. The limited processing capability, memory, and storage space on the pluggable transceivers require the use of highly efficient protocols.

6.2 CMIS

The OIF defines the common management interface specification (CMIS) and release 5.3 has been published [2].

It defines registers that the host device uses to control pluggable interfaces to the through a serial interface to connect on the host board connector.

Open XR Optics Forum is defining additional registers to support Open XR Optics pluggable interfaces in existing CMIS releases. This includes an approach to configure point-to-multipoint networks via existing CMIS commands.

In addition, Open XR Optics Forum members participate in the OIF to introduce registers in CMIS release 5.3 and following to include additional support for the configuration of subcarriers at 25 Gbit/s granularity in point-to-multipoint scenarios.

6.3 Equipment API, OpenConfig

There are two key options for this available in the market: OpenConfig covers a very wide range of use-cases across network layers 0 to 3 from DWDM to IP. The OpenROADM MSA strongly focuses on the DWDM layer in OpenROADM MSA.

Due to its coverage of packet equipment's north bound API, the data model defined in OpenConfig is the main option required for the deployment on open XR optics forum interfaces.

6.4 Controller NBI T-API

Many Open XR Optics Forum members prefer T-API as a controller NBI within the hierarchy of SDN controllers.

6.5 Short term: automatic setup via CM application

One option to automate the set up the connectivity required for host independent management of XR modules is to use the so-called configuration manager application. It is a SW application that runs on the host equipment and establishes the connections needed between the Open XR Optics controller and the Open XR pluggables.

6.6 Short term: Role of the Open XR Optics Controller

The Open XR Optics controller serves as a SW instance that provides a network view of the Open XR Optics pluggables within a domain. It adapts the host independent host API of Open XR Optics pluggables to a network level API including topology information such as T-API or a REST based NBI.

This whitepaper will help the Open XR Optics Forum to define the role of the Open XR Optics controller more clearly.

6.7 Streaming telemetry

Streaming telemetry will use the OpenConfig models via gRPC. This aligns with the earlier OpenConfig discussion.

6.8 Longer term management implementation

Most participants prefer direct management of pluggables without a separate XR controller via a CMIS adaptor if needed. If an XR controller is needed, it should be standard and open source. The longer-term vision is that there should be no vendor-proprietary EMS or controller in the provisioning flow.

7 Related open initiatives and standardization activities

7.1 Related work in other organizations

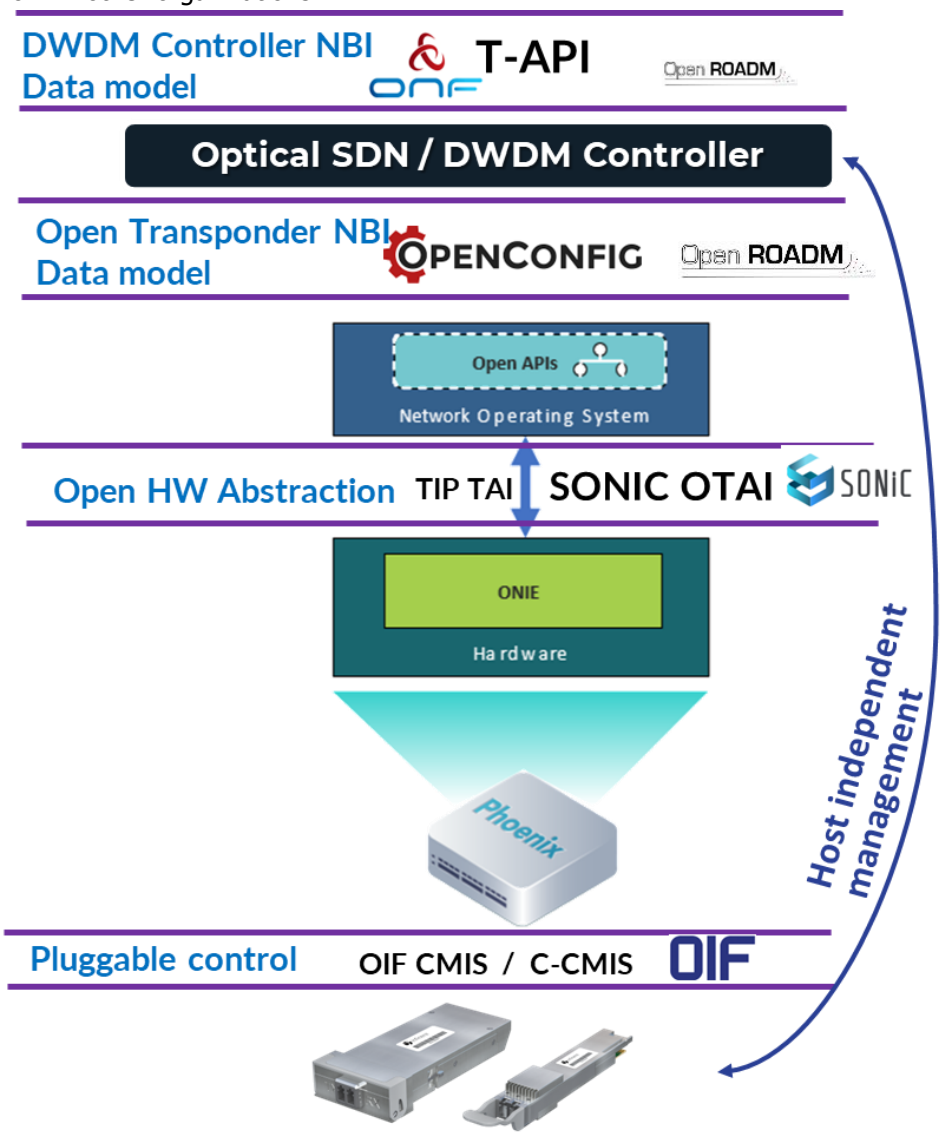

Figure 9: The roles of different API definitions in the ecosystem of open initiatives.

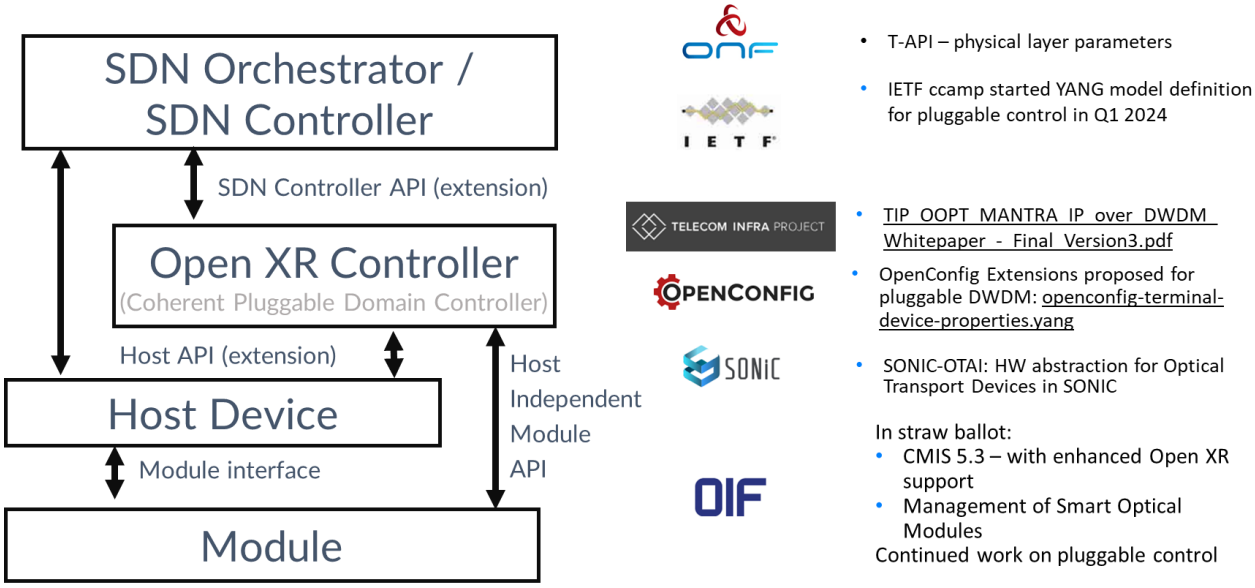

Figure 10: Open XR optics forum management architecture [1] and related industry initiatives.

8 Recommendations

8.1 Further Evaluation Required

The requirements discussed in this whitepaper are applicable to a wide range of network use-cases in packet aggregation. Further evaluation is necessary to ensure their validity in the context of OpenRAN or PON overlay use-cases.ss

8.2 Standards Activities outside Open XR Optics Forum

There are currently several activities in the industry around the definition of open information models for the control of coherent DWDM interfaces and pluggable interfaces in OIF [2, 3], IETF [4], OpenConfig [5], TIP MUST [6]. Open XR Optics forum members will need to observe and actively engage in these activities to ensure alignment and applicability to Open XR pluggable interfaces.

8.3 Open XR Optics Forum Next Steps / Workstreams to start

To drive the standards engagement required (see section above), this Open XR Optics Forum workstream recommends that:

- Open XR Optics Forum starts a workstream to evaluate current OpenConfig models for their applicability to the use-cases of Open XR. The output of this workstream should be an analysis of potential gaps in OpenConfig definition as well as a proposal to extend OpenConfig to support Open XR functionality.
- A similar approach should be taken for the IETF pluggable modeling started beginning of the year. Here, it may be possible to provide input in an earlier stage as the activity has not formally released its first version yet.

9 References

[1] Open XR Optics Forum, "Open XR Management Architecture Specification, OXR.NETMGMT.01.0," 2022.

[2] OIF, "Common Management Interface Specification (CMIS) - Revision 5.3," 2024.

[3] N. L. Swenson, S. J. Hand, D. Hillerkuss, I. Alderdice and S. Gareau, "White Paper: Management of Smart Optical Modules - OIF-MGMT-Smart-Modules-01.0," 2024.

[4] IETF, "IETF Common Control and Measurement Plane (CCAMP)," 2024. [Online]. Available: https://datatracker.ietf.org/wg/ccamp/documents/.

[5] TIP, "OpenConfig extensions by TIP," [Online]. Available: https://github.com/openconfig/public/pull/911.

[6] O. González de Dios, J. P. Fernández-Palacios Giménez, S. Melin, R. Diaz, J.-F. Bouquier, J. A. Gómez, D. Breuer, S. Hill, E. Lerouzic, K. Coskun, R. Bozaci and A. M. López de Lerma, "TIP MANTRA Whitepaper," 2022.