Open XR Management Architecture Specification

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Abstract: This document specifies the architecture for management of Open XR Networks

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 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

The introduction of point-to-multipoint optical transmission technology in operator networks raises operational network management questions, particularly regarding the commissioning/management of subcarriers and the abstraction of the point-to-multipoint (P2MP) data flows.

The trend towards disaggregation adds complexity at the network management level when DWDM transceivers are productized in pluggable form factors for use in 3rd party routers. This issue is not limited to P2MP optical technology, but is industry-wide, and applies to any type of advanced DWDM pluggable optic.

This document addresses an architecture for disaggregating the management of Open XR pluggable modules installed in 3rd party host routers while enabling provisioning of digital subcarrier-based [1] network topologies, remote management over the optical link, and advanced telemetry monitoring.

2 Scope

This document specifies the architecture for network management in Open XR networks. It is focused on point-to-multipoint applications, as these applications introduce new challenges for smart modules installed in third-party hosts. This specification allocates functions between transport-centric smart pluggable OpenXR modules, packet-centric routers that host those smart modules, a software agent running on the host router, and a cloud-based network controller. Other documents will provide detailed specifications for these components.

3 Capabilities

3.1 Separation of IP Layer Management and Transport Management

Service provider organizations often have separate personnel groups manage the IP network infrastructure and the transport infrastructure. A traditional partition of functions and network architecture is shown in Figure 1. Transport personnel would typically manage the portions of the

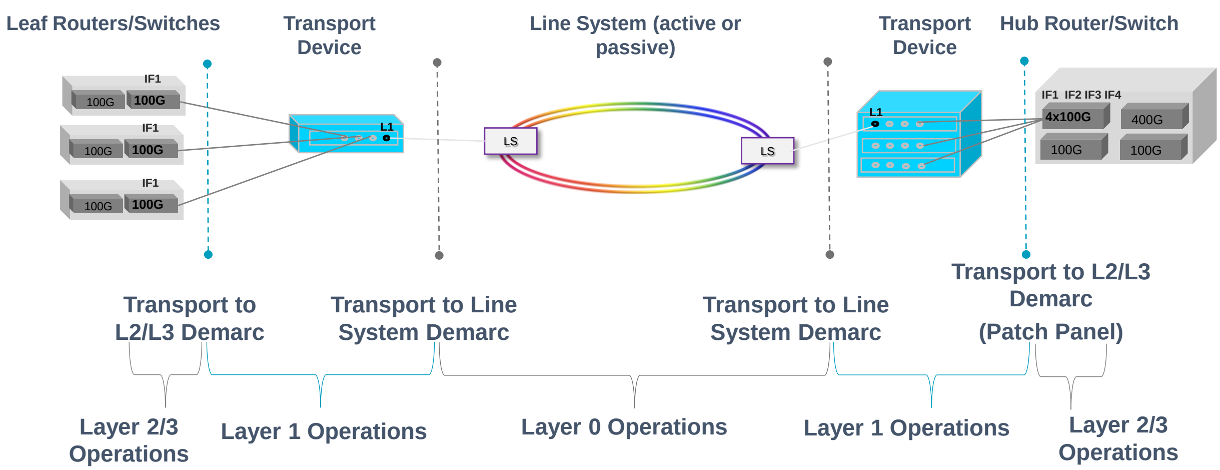

Figure 1. Traditional network architecture and functional management partition.

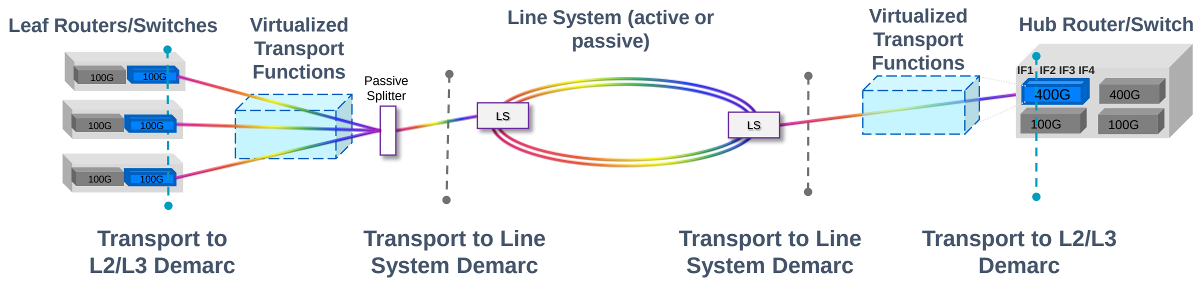

Figure 2. Open XR network architecture and functional management partition.

network between the two "Transport to L2/L3" demarcation points. IP personnel would manage the router/switches outside those two demarcation points.

With Open XR, smart pluggable modules (embedded within Layer 3 routers) subsume transport features that traditionally resided in separate DWDM transponder chassis. This is illustrated in Figure 2, where the virtual transport functions are absorbed into the Open XR modules residing in the router chassis. The Open XR management architecture supports traditional management of Layer 3 routers by IP layer personnel while providing a means for transport layer personnel to seamlessly manage the transport features provided by the smart pluggable modules.

3.2 Decoupling of Development Timelines for Routers and Smart Optical Modules

Current state-of-the-art module management utilizes register-based standardized information models that router hosts and pluggable modules must support to achieve interoperability. To introduce a new DWDM transceiver technology, updates to standardized information models need to be agreed upon and implemented within both the smart optical modules and routers, tying together development and deployment cycles, which can delay technology adoption.

The Open XR network architecture decouples these development timelines by managing the smart optical modules by the Open XR Controller. The Open XR Controller communicates with Open XR module through a combination of data plane and/or standardized DCN Ethernet ports on the router. To facilitate this, a Communication Agent Service is specified that runs on the host router. This Service passes messages received from the Open XR Controller on the host DCN port to the embedded pluggable module. Details of how messages destined for the Open XR module are routed to the module will be provided in a subsequent specification for the Communication Agent Service. The Communication Agent Service is intended to be a pass-through function that does not require frequent updates as the features of the smart pluggable module evolve over time.

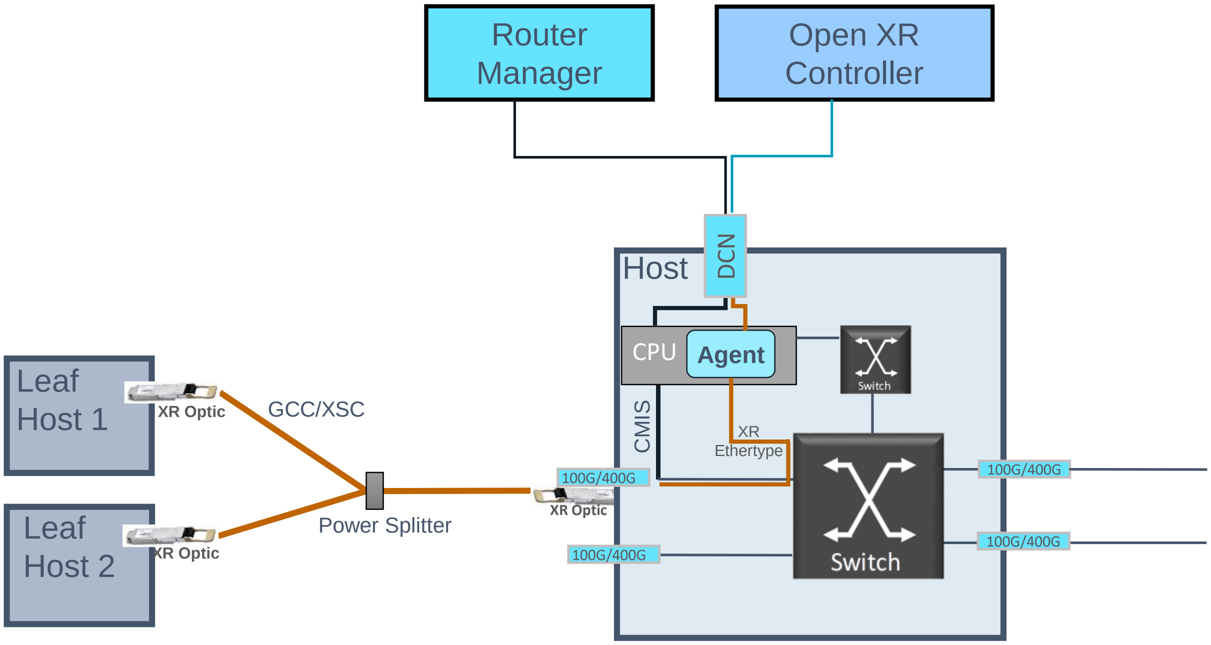

Figure 3. Leaf Hosts remotely managed via GCC/XSC over Open XR link.

3.3 Remote Management

In addition to management of the Open XR pluggable module through the host router in which that module is mounted, an additional path is made available to manage an Open XR module at the remote end of an Open XR link via a GCC/XSC (General Communication Channel/XR Supervisory Channel). This allows a demarcation point at the electrical interface of an Open XR module for those modules that are plugged into customer-owned equipment, where a DCN connection to the router is not available. This is shown in Figure 3.

3.4 Dynamic Bandwidth Allocation

A primary advantage of an Open XR network is the ability to dynamically allocate bandwidth via subcarrier assignment without requiring a truck roll. This feature requires intelligence about the overall network topology that does not reside in a single pluggable module device. The Open XR management architecture supports this through the Open XR Controller.

3.5 Advanced Transport Monitoring Features

An Open XR network based on digital subcarriers enables fine-grained transport diagnostic capabilities that transcend those of a traditional DWDM network. The Open XR Controller communicates with the individual modules to collect data used to formulate an in-depth view of the transport network health and status.

3.6 Security

The Open XR network architecture must provide a secure operating environment with robust protection against a myriad of on-line threats. The Microsoft STRIDE threat model [2,3] identifies a framework for evaluating various threats:

- (S)poofing identity,
- (T)ampering with data,
- (R)epudiation threats,
- (I)nformation disclosure,
- (D)enial of service and
- (E)levation of privileges.
-

With fully automated onboarding and provisioning of Open XR devices, we must protect against intruders interfering with the configuration of devices or introducing hostile devices in the network. In accordance with the Open Connectivity Framework specifications, this is secured with X.509 TLS certificates, which are allocated and managed automatically without any manual intervention by the end user. Open XR Devices and the Open XR Controller can authenticate towards each other, and secure traffic between them, with these mechanisms.

With the device using TLS certificates, the framework for TLS authentication and encryption can also be used to protect the module’s communication interfaces.

Software that runs on the Open XR Module is protected with a Secure Boot mechanism, where the manufacturer signs all firmware/software that is authorized to run on the device.

Details of security measures are covered in a separate Open XR specification.

4 Overall Architecture

Figure 4 shows the overall architecture of the Open XR management structure. Two paths are shown for management of the pluggable module. Management of a module plugged into the router is traditionally handled by the router. The router itself may be managed via a command line interface (not shown) or via a server/cloud-based router manager software package which in turn communicates with the back office operational support system (OSS) through a northbound interface (NBI). This management path, which is shown on the left and designated Path 1, provides traditional functionality such as module recognition, host lane recognition, module initialization, etc. It uses a register-based information model and management through such agreements as CMIS [4], C-CMIS [5], and the CFP MIS [6] using either a two-wire interface (TWI, also known as I^{2}C) or MDIO.

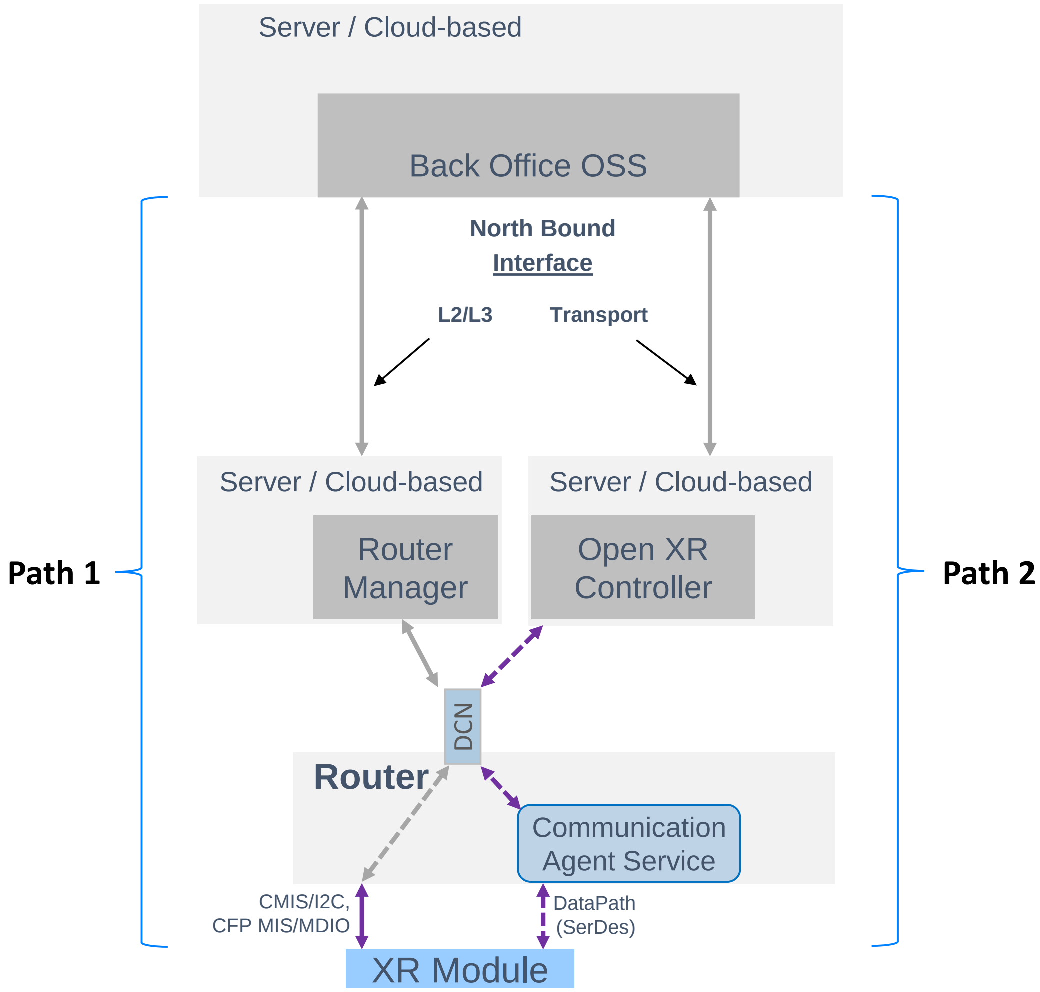

Figure 4. Open XR Management Architecture

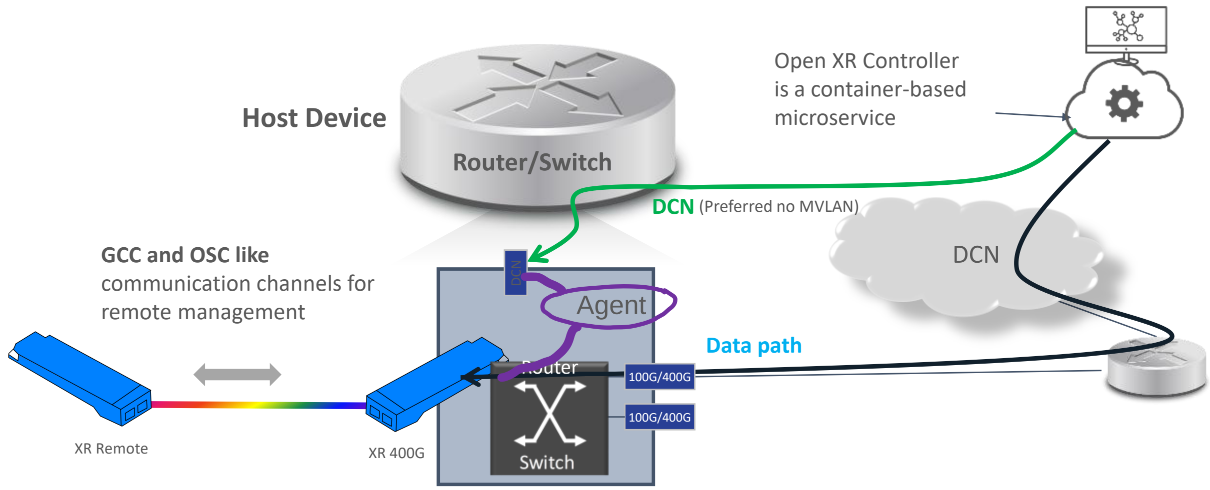

Figure 5. Open XR module management via data path

The path on the right, designated Path 2, is a new management path introduced as part of the Open XR management architecture. The back office OSS communicates through a NBI to a server/cloud-based Open XR Controller, which in turn communicates with the router through the router DCN port. When messages from the Open XR Controller and destined for the Open XR module are received by the router, they are handled by the Communication Agent Service running on the router. These messages are forwarded to the data path entering the Open XR module via the module host electrical lanes where they are recognized as management/control messages and handled appropriately. Details of this forwarding mechanism will be specified in a later document.

The two paths to the module shown in Figure 4 constitute a "Dual Management" approach where there is a clear separation of control functions. The host management has responsibility to bring up the module on installation, manage the module SerDes and lane assignment, and monitor alarm registers. This is further described in Section 4.1. The Open XR Controller then has responsibility for setting optical parameters, including wavelength, subcarrier assignment, and power levels, as further detailed in Section 4.2.

In addition to management of the Open XR modules through the DCN port of the host router, the architecture supports a second management scheme that supports communication between the Open XR Controller and the Open XR module via the data path. This method requires the use of management VLAN assignments to carry traffic between the Open XR Controller and the Open XR module. This is illustrated in Figure 5, using the path labeled "Data path". (Management via the router DCN port and remote management are also shown for comparison.) Messages from the Open XR Controller to the Open XR module can enter the router through any of the router data ports. They are then forwarded via the router/switch to the SERDES of the destination Open XR module. The advantage of the data path approach is that it can be used for routers that are not running the Communications Agent Service. The disadvantage is that it requires assignment and management of VLANs for management purposes.

4.1 Host Management (Path 1)

As described above, host management has responsibility to bring up the module on installation and manage the module SerDes and client lane assignments to define the interfaces (e.g., Ethernet interfaces). Upon insertion of the module to the router, the module advertises SERDES configurations and speeds that it offers on its host interface. The router controls this configuration and assigns logical lanes to the physical SERDES lanes. The router also monitors alarm registers. Path 1 controls the attributes that define the interface between the host and the Open XR modules as shown in Figure 2. With respect to separation of control, these functions are only controlled by Path 1. The Open XR Controller is made aware of these attributes but does not control or write to these attributes.

Furthermore, for some modes of operation, such as Point-to-Point, and 4x100 Point-to-Multipoint ("Breakout" mode) the host management Path 1 is sufficient and does not require Path 2, provided default values for transport specific values are available and used.

4.2 Open XR Controller (Path 2)

Once initialized, the Open XR module communicates with the Open XR Controller and Path 2 is established between the two. The Open XR Controller performs the following functions: module discovery and inventory, host/module association, network topology discovery, subcarrier assignment, bandwidth allocation, performance and alarm monitoring, and advanced diagnostics and troubleshooting of the optical transport layer. Tradeoffs between modulation, baud rate, and reach are handled by the Open XR Controller. Just as Path 1 controls the attributes that define the interface between the host and the Open XR modules, Path 2 controls the attributes that define the virtualized transport functions and the demarcation interface between the Open XR modules and the Line System as shown in figure 2.

Concentration of the transport functions in an intelligent container-based microservice simplifies deployment and facilitates rapid introduction of Open XR features. The Open XR Controller is portable and can be hosted in the most appropriate location (for example, close to the edge in a latency-sensitive application). With the Open XR controller responsible for transport features of the link, the router need not be concerned with coordination of subcarriers or tradeoff of modulation versus reach.

4.3 Northbound Interface of Open XR Controller

The northbound interface (NBI) of the Open XR Controller provides a standardized software interface to the service provider OSS. The NBI is based on a YANG model of network elements and network state and is realized via application programming interfaces (APIs) based on the RESTCONF protocol. This standardized northbound interface will be defined in a subsequent document.

4.4 Communication Agent

Communication between the Open XR Controller and the Open XR module installed in a host router via the router DCN port is facilitated by a Communication Agent running on the router host. The Communication Agent is a service application that enables an IP path between the Open XR Controller and the pluggable module using an address scheme localized within the host router. The Communication Agent Service participates in onboarding the module and provides address translation for incoming/outgoing messages from/to the Open XR Controller. This is described in more detail in the next section.

5 Pluggable Module

The Open XR Pluggable Module can have various form factors. For the management discussion here, we will assume that the module is QSFP-DD. Management will be similar for a QSFP-28 or CFP2.

The module register map and capability advertisement will be consistent with CMIS[4] and C-CMIS[5] and communication with the host router will be via I2C (alternatively called Two Wire Interface, TWI)[1].

5.1 Onboarding with Communication Agent

Upon insertion of the module, the host router powers up the module and reads the module register map to establish module capabilities. The host enables SERDES lanes and appropriate host-side FEC and sets up a Layer 2 link with the Communication Agent. The host provides network information to the Communication Agent so that it can address the module. The Communication Agent discovers the MAC address of the module and link local IP address. The Agent informs the module of the IP address for the Open XR Controller so that the module can "phone home". The Agent performs any network address port translation required to set up a link between the module and the Open XR Controller through the router DCN port. The Open XR Controller notes the new module on the network, associating the module with a particular router and location. The Open XR Controller establishes a reverse direction communications link and starts configuration of the optical characteristics of the module.

5.2 Onboarding without Communication Agent

If the Open XR module is hosted in a router that has not implemented the Communication Agent, the module will use a Management VLAN to communicate with the Open XR Controller over the data path as opposed to the DCN port. This management path, which was discussed in Section 4 in reference to Figure 5, is used for onboarding as well as all other management functions. While it has the advantage on not requiring a Communication Agent running in the host router, it has the disadvantage of requiring the administration and allocation of Management VLAN addresses.

5.3 Management Relay Capability

As described in Section 3.3, remote management of Open XR modules is an important aspect of the Open XR Management Architecture. This enables the Open XR Controller to manage an Open XR module installed in a router even when there is no DCN connectivity between that router and the Open XR Controller. This requires an Open XR Module to distinguish between management packets destined for that module from those destined for a module further downstream from the Open XR Controller. To that end, the Open XR Module provides a bridging function between its electrical and optical ports, filtering packets depending on their destination. Moreover, a robust supervisory communication channel must be established between the two modules to assist with onboarding of the remote module before the digital subcarriers of the remote module are fully configured.

[1] For a CFP2 module, communication is via MDIO and the register map is governed by the CFP MIS[6].

6 References

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