# White Paper: Management of Smart Optical Modules

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**Working Group:** **Physical Link Layer Working Group**

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**ABSTRACT:** Current paradigms for managing pluggable optical modules require tight coupling between the host and module. This White Paper describes a new paradigm that decouples the controller from host SW development, enabling faster realization of advanced module capabilities in a disaggregated environment.

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# 1 Introduction

The advent of coherent optical technology that fits within a compact pluggable module has brought widespread deployment of IP over DWDM (IPoDWDM) closer to reality. One challenge that remains is the efficient management of the advanced features enabled in these coherent pluggable modules. The current management methodology for IPoDWDM requires tight coupling between hosts and pluggable optical modules.

The host equipment, which includes different types of data transport equipment (such as IP routers, Ethernet switches, or access switches) controls all aspects of an interface module or port that relate to packet functionality. Port operational status, packet layer alarms, performance monitoring and similar operational aspects related to layer 2 (L2) or layer 3 (L3) functionality all are under the direct control of host software and its packet software-defined networking (SDN) control functionality. These packet functionalities are fixed and highly abstracted so as to be common for very different kinds of pluggable interfaces; for example, grey short reach pluggable interfaces, active optical cables (AOCs) or direct-attach copper (DAC) cables, and high performance DWDM modules.[1]

The same paradigm is generally used for DWDM functionalities of these ports as well, which can create a significant burden to update both host software and packet SDN controller software as DWDM capabilities evolve with new and changing functionality. Those capabilities do not relate to the packet network directly and do not interact with packet control software such as packet routing or virtual local area network (VLAN) functionality. As DWDM module capabilities advance, updating both host and controller software significantly delays deployment of optical capabilities and significantly increases overall software complexity. In multi-vendor disaggregated environments, it is becoming challenging for the various host system suppliers to implement and track the advanced features implemented by the various DWDM module vendors.

In other words, a packet layer requires an abstract set of information on network layers 0 and 1, such as abstract topology information, adjacencies, packet statistics, port administrative status, etc. Information on physical layer parameters, such as modulation (for a given data rate), power level or wavelength, are not relevant for the operation of the packet network, even though their correct setting is a prerequisite for the actual packet network function.

In this white paper we explore how the DWDM functions, parameters, and operational aspects of “smart” optical pluggable modules can be handled more efficiently in order to deal with the challenges described above. Those functionalities differ significantly over diverse types of modules and change over time as new technologies and capabilities are introduced, which happens at a fast pace in the disaggregated networks being deployed today.[2]

[1] As used in this white paper, Layer 3 refers to the network layer, typically IP, and Layer 2 refers to the data link layer, typically Ethernet. Layer1/Layer0 refers to the physical layer, with Layer 0 referring to a purely photonic network layer, including DWDM and ROADMs.

[2] While this white paper proposes a new management paradigm based on packet communication between an optical controller and the smart optical module, it should be mentioned that CMIS evolution (including advertisement-based management, allowance for vendor-specific features, CDB programmability, and plug-and play capabilities) offers alternative methods to achieve similar objectives.

A smart optical module is a module that can be directly reached for control purposes via the operator's data communications network (DCN). For the purposes of this white paper, a *smart optical module* [1, Sec. IV.C] is an optical module with three defining characteristics: it can be managed with a packet-based management scheme[3], it is separately addressable via its own unique address (for example, without restriction, an IP or Ethernet address), and it provides a demarcation point between the L2/L3 network and the transport network by introducing a virtualized transponder. This is described in more detail below.

# 2 Scope

This white paper introduces a control paradigm for optical modules that decouples optical layer control from packet layer control and thus, from host software and packet controller software development. This paradigm is called “host independent management”, enabling advanced capabilities of smart optical modules via additional management methods. These methods allow a controller that does not reside on the host to manage the module’s advanced capabilities. It proposes an architectural model for the management plane that separates advanced module features (e.g., line transmission modes, telemetry, optical settings, etc.) from basic control and alleviates the host software from needing to be customized in order to manage those advanced module features. The host developer no longer needs to update software to support new optical capabilities of pluggable modules that maintain similar host specific characteristics. This also enables an operator to disaggregate host functions from optical functions, facilitating rapid deployment of new features in a disaggregated environment. This white paper, while focused on management of a pluggable module in a packet-layer host, also applies to a wide variety of hosts.

While this white paper introduces this new management paradigm and architecture, specific implementation details and methods are outside of its scope. We anticipate that a future OIF project may address further details implementing the model envisaged herein.

# 3 Current Module Management Paradigm

## 3.1 Current Management Architecture

In the current management architecture, management of the DWDM optical module is entirely the responsibility of the host device. Some capabilities can be introduced thru AppSel advertisement/selection. However, other features, such as advanced diagnostics and troubleshooting, require interaction in order to manage the optical module. In these cases, the host management software is required to support these module features, resulting in longer times for new features to be deployed due to the need to update both host management software and module software. Also, a large variety of different host devices (potentially from different vendors with different software upgrade timetables) may need to be updated before the new feature can be deployed across the network, further delaying deployment of the new features. This results in larger than linear scaling of implementation effort (product of number of host variants and pluggable variants).

[3] This is not meant to imply that the management protocol is necessarily a packet protocol. Rather, management directives and responses can be communicated with the module by encapsulating such directive/response in a packet (for example, without restriction, IP or Ethernet).

### 3.2 Current Module Interfaces

The current host/module software interface, for example using CMIS, is register based, supporting basic functionality, limited speed of communication, and limited expandability due to address/register space limitations. The electrical interface is usually a serial bus interface, such as the Two-Wire Interface ($I^2C$) or alternatively MDIO (for the CFP family of modules).

## 4 New Packet-Based Smart Module Management Paradigm

The new smart module management paradigm proposed in this paper moves management of complex module features from the host's management software to a separate dedicated controller, eliminating the requirement for host software to be continually updated as new interactive features are added to the optical module. The optical controller can be executed either directly on the host or remotely within the operator's network.

For smart optical modules as defined in this white paper, the new paradigm proposes utilization of a high speed, packet-based management channel between module and remote controller rather than the current register-based interfaces. This improves speed of communication, flexibility, and expandability of the management interface and leverages mature packet handling functions supported by the host device.

## 5 Desired Capabilities

### 5.1 Separation of Host-Related Management and Optical Layer Management

Service provider organizations have traditionally had separate personnel groups with different areas of expertise managing the Packet and Transport layer infrastructures. Transport personnel have typically managed the portions of the network between the two “Transport-to-L2/L3 demarcation” points shown in Figure 1. Packet layer personnel have managed the router/switches outside those two demarcation points. (With IPoDWDM becoming more prevalent, some service providers are merging the IP and Optical management teams into a single organization; this organizational structure is also supported by the approach proposed in this white paper.)

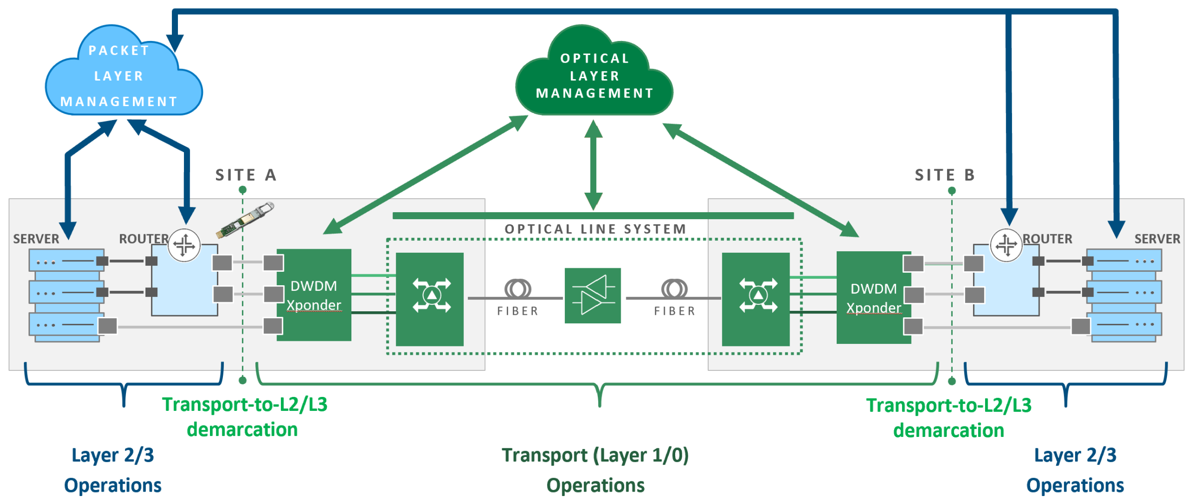


**Figure 1. Traditional network architecture with physical demarcation points between transport equipment and L2/L3 host equipment.**

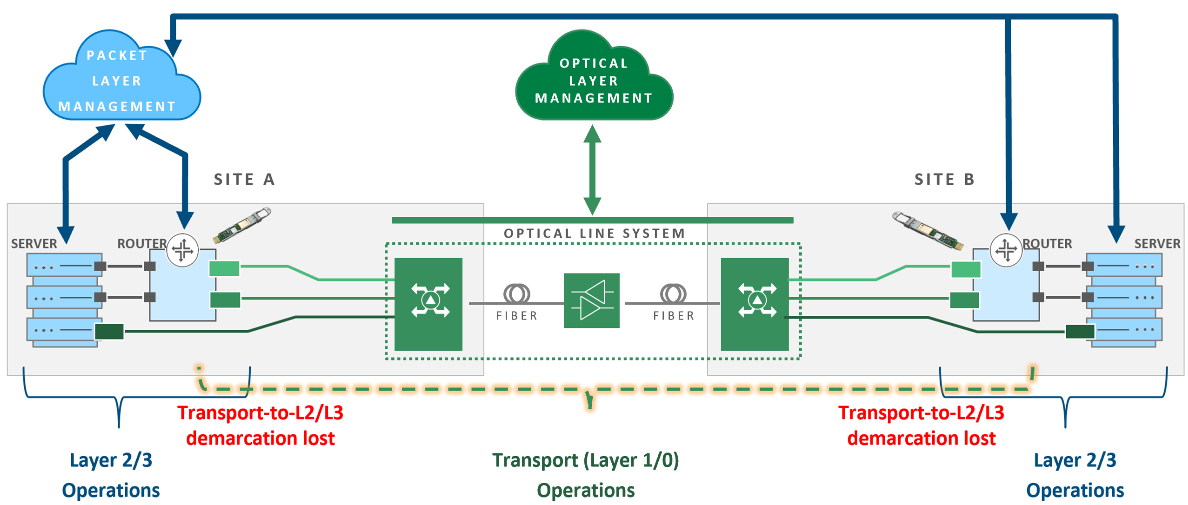


**Figure 2. Router integrated IPoDWDM. The physical demarcation between packet and optical domains is no longer present.**

The DWDM transponder shown in Figure 1 converts between client-side optical links (connected to the L2/L3 host) and line-side optical links connected to the optical line system. The emergence of coherent pluggable optical modules with advanced transponder features has obviated the need for a separate DWDM transponder chassis, enabling insertion of advanced coherent modules directly into ports of the L2/L3 host, as shown in Figure 2. With this evolution, advanced methods of end-to-end link training to improve link performance between routers at both ends of the link have been developed. But this realization of IPoDWDM requires management of the optical layer functions by a host router, complicating the separation of lower layer control from the higher layer controller and creating challenges for

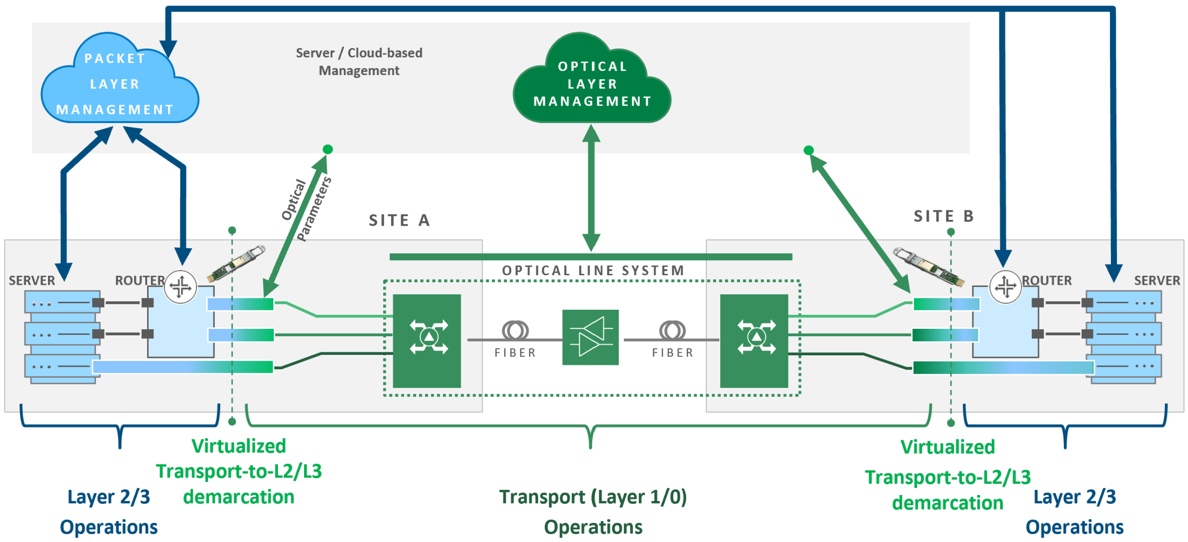


**Figure 3. Virtualized demarcation between packet and optical domains with smart pluggable modules: the hardware demarcation moves into software.**

network operators. As Figure 2 shows, the physical partition and demarcation of functions between packet and optical transport equipment is no longer present.

This white paper proposes to address this management challenge through the introduction of optional capabilities which, if supported, define a category of *smart pluggable modules* whose transport features can 1) be managed via a packet communication channel, 2) be addressed independently of the host, and 3) establish a demarcation point between the optical transport layer and higher networking layers. The transport features previously provided by the separate transponder chassis are "virtualized" and provided by the smart optical module acting as a *virtual transponder*. While the separate transponder chassis in Figure 1 converts between the client-side optical links and the transport optical links, the client-side optical links are no longer required. The proposed management architecture supports the traditional management of layer 3 routers by IP layer experts while providing a means for transport layer experts to seamlessly manage the transport features introduced by the smart pluggable modules. This will accelerate the adoption and deployment into a growing variety of host systems (e.g., layer 3 router or layer 2 switch hosts). This is illustrated in Figure 3, where the virtual transponder features are available in the smart pluggable modules and the physical demarcation point becomes a *virtualized demarcation point* within the virtual transponder. The virtual demarcation point defines an abstract boundary between the module features that are managed by the packet controller versus those managed by the optical controller.

Note in Figure 3 that optical transport parameters originate at the Optical Layer Management. The path to the smart optical module is not explicitly shown in the figure. This topic is being discussed and is evolving in various industry groups and standards bodies (for example, TIP and IETF); some advocate a direct path from the Optical Layer Management to the module, while others advocate that the Optical Layer Management should only communicate with the module through the Packet Layer Management to avoid synchronization issues. This white paper takes no position on which alternative is preferable but merely advocates that there are two types of controllers, one managing the packet parameters and the

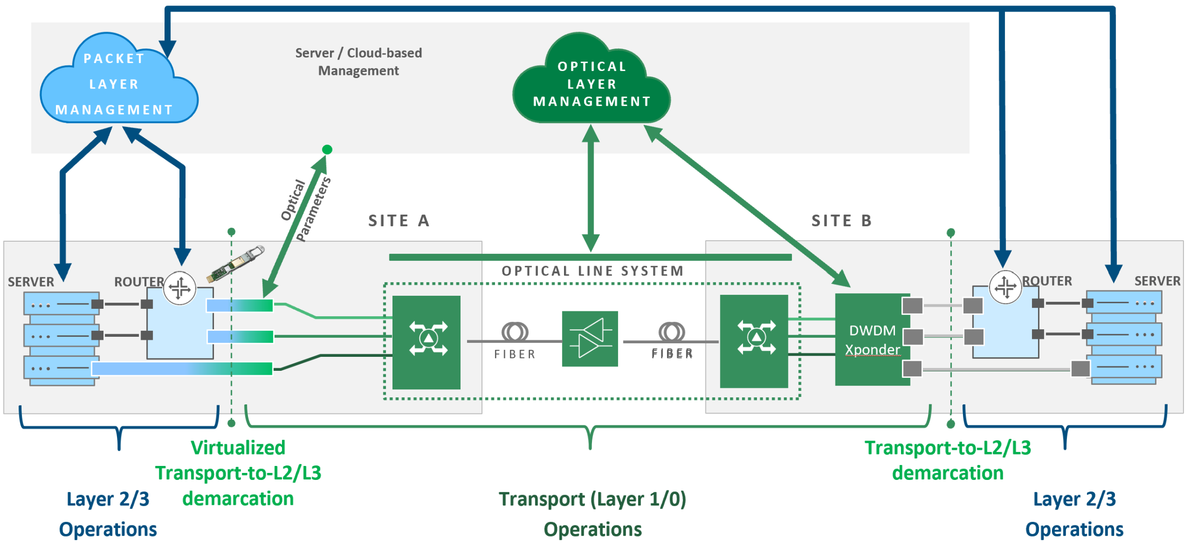


**Figure 4. Coexistence of host independent management and traditional management.**

other managing the optical parameters of the smart optical module. TIP and other forums discuss various options and the pros/cons to coordinate between the packet and optical controllers using a higher SDN layer or orchestrator. It is feasible to have multiple vendor specific smart optical controllers until features are standardized. While there is additional effort required to integrate several vendor-specific optical controllers, that additional burden enables more rapid deployment of advanced vendor-specific features.

Of course, conversion to a new management paradigm will not happen instantaneously or universally, and any such management scheme must be backwards compatible with the present mode of operation shown in Figure 1. It is easy to envision a network with smart pluggable modules and the virtualized demarcation points shown in Figure 3 coexisting with network elements with physical demarcation points under traditional network management as shown in Figure 1. This is illustrated in Figure 4, where smart modules managed via the new paradigm are communicating with network elements that are traditionally managed.

While these figures illustrate two-ended connections, the concepts described are fully compatible with a multitude of network end points, with some nodes managed via the new management paradigm and other elements managed traditionally.

## 5.2 Relationship to Other Standards

Other standard development organizations have recognized the challenges presented with open, disaggregated networks. The TIP OOPT Target Architecture [2] has the objective to decouple the lifecycles of Open-Optical Terminals (O-OT) and Open-Optical Line Systems (O-OLS). To this end, TIP has proposed an option for module management that utilizes dual management by the IP and the Optical Controllers (defined as “Proposal 1 – Dual SBI management of IPoWDM routers” [3]). In the TIP Proposal 1, the IP Controller management of the optical attributes is currently limited to the following four attributes: target-central-frequency, target-output-power, operational-mode, and admin-state on/off, while the Optical Controller is limited to read-only access of these four attributes to avoid any synchronization issues with the router's configuration management. The paradigm described in this paper supports the TIP objective of decoupling lifecycles of optical terminals and optical line systems and goes one step further decoupling the lifecycles of the optical terminal (smart pluggable) and the host system software. An operator may choose to adopt the baseline functionality of the TIP Proposal 1 model, assigning management of the four attributes mentioned above to the IP Controller, while augmenting the TIP Proposal 1 to allow the Optical Controller to access more specialized, non-overlapping functions. Alternatively, a more general-purpose authorization mechanism can be used to determine which functions can be accessed by each controller.

Similar dual management systems have already been defined in other technologies. For example, in Open RAN architecture the Radio Unit (RU) can be managed through its parent Distributed Unit (DU), or also separately by an entity such as a management system, using authorization mechanisms to determine which functions are accessible to the DU and which to the management system [4]. The management system can be allowed access to RU software management, performance management, configuration management and fault management.

## 5.3 Decoupling of Development Timelines for Hosts and Smart Optical Modules

Current module management utilizes register based MSA information models that router hosts and pluggable modules must support to achieve interoperability. To introduce a new DWDM transceiver technology in a disaggregated environment, the relevant MSA organization needs to agree to changes in the MSA information model and said changes then need to be implemented within both the smart optical modules and the associated hosts (e.g., routers). This process begins with MSA convergence, then module and host vendor development, and finally operator verification, integration, and deployment, all of which lengthens the adoption cycles for new technology. This is especially challenging in diverse disaggregated networks, where many different transceiver and host vendors are expected to be deployed into the same network.

The proposed management architecture decouples these co-development timelines by enabling advanced functionalities of the smart optical modules to be managed via a separate dedicated optical transport controller, independent of software updates in the host.

As we look towards the future, bandwidth demands will continue to increase, pushing all the way to the access network. The architecture of the future will need to account for simple white box type devices with embedded advanced optical modules that can be managed independently of the core host device management system. New host types must also be considered for advanced module deployment, e.g., insertion of a smart module directly into an edge compute server instead of a router.

## 5.4 Advanced Transport Monitoring Features

Advanced coherent modules can provide more advanced optical layer monitoring but are limited by the bandwidth of current serial bus interfaces and the one-way nature of these interfaces. Moving to higher bandwidth interfaces allows smart modules to support data streaming for advanced optical performance monitoring, for example constellation streaming. Higher bandwidth interfaces also allow packet layer data, like RMON counters, to be retrieved at faster intervals without consuming the entire management interface. Other performance monitoring can focus on layer 1 technologies, such as OTN, which are typically foreign to L3 routers and L2 switches. Workarounds that are currently employed, such as suspending PM capture during module software upgrades, will no longer be necessary.

The one-way nature of a serial bus like $I^2C$ means that the host controls the bus and initiates all transactions. This, coupled with the single interrupt configuration on current modules, means that many defects/alarms/flags must be polled. A more advanced interface would allow these alarms to be pushed or streamed, reducing the real time impact on the host of polling multiple alarm points, all while providing faster notifications.

To facilitate this, the proposed high-speed communication channel between a smart module and a controller is envisioned to carry streaming performance data. This can be enabled either through a vendor specific in-band management virtual local area network (MVLAN) or an out-of-band management connection through the host DCN port.

Furthermore, the communication channel can be easily managed through standard technologies and functions that exist on many higher layer hosts, like virtualized routing and forwarding (VRF) which is available in existing router network operating systems. It is also possible to manually configure management VLANs to pass traffic between the optical transport controller and the smart optical pluggable module.

One tradeoff in supporting a fast module management interface (for operations like module software updates) is that as the number of ports scales, the architecture of the host management must be evaluated to ensure that there are no points of congestion. Furthermore, the addition of VRF and MVLAN based forwarding will require additional configuration overhead, which will scale with the number of modules from different vendors present in the host. While these issues must be addressed, the details are beyond the scope of this white paper.

## 5.5 Advanced Management Communication Functionality

The proposed packet-based connectivity path for optical module management allows for the introduction of additional advanced management capabilities such as:

- Fast Firmware upgrade through new protocols (e.g., SFTP)
- More efficient and lightweight message-based management
- Streaming of alarms, logs, and telemetry
- CMIS register read/write through a packet interface

## 5.6 Security

Moving to management interfaces that are not limited to the local connection between module and host raises security questions. The ability for Optical Layer Management to reach through the host to manage the module will require security methods substantially identical to those currently used to secure communications between the Packet Layer Management and the Router (or between the Optical Layer Management and the Transponder) in Figure 1. These mechanisms include topics such as authentication, encryption, and protection against unauthorized access and denial of service attacks. Best practices for secure remote management of network elements use standardized and accepted security protocols. Similar techniques can be used to secure the connections to smart pluggable transceivers.

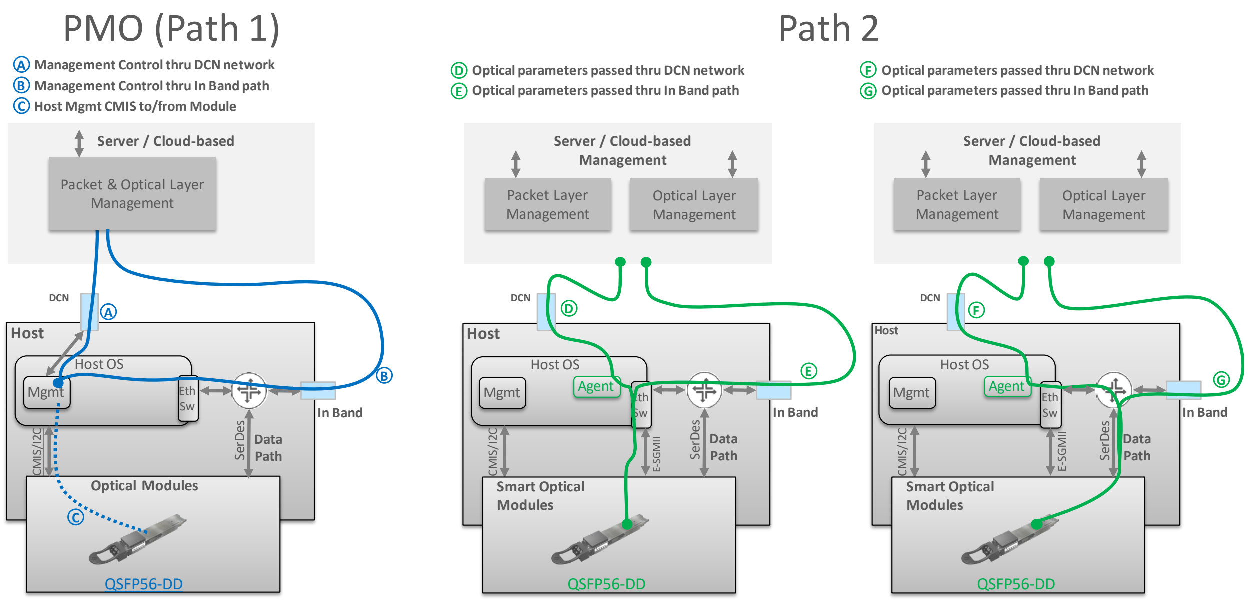


**Figure 5. Proposed Management Architecture. Packet Layer management (PMO, Path 1) and Optical Transport Layer management (Path 2)**

## 6 Overall Architecture

Overall management architecture and multiple paths for management of the smart pluggable module are shown in Figure 5. The standard management infrastructure or Present Mode of Operation (PMO) for pluggable modules is maintained and unchanged as Path 1 for management of the Packet Layer. 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 1, which is shown on the left, provides traditional functionality such as module recognition, host lane recognition, module initialization, etc. Management packets terminate in the host and are converted to appropriate module commands and communicated over a serial bus interface to the module, shown as a dotted line in Path 1. Depending on the module form factor, management communication between the host and module typically uses a register-based information model through such agreements as CMIS [5], C-CMIS [6], and the CFP MIS [7] using serial bus interfaces like $I^2C$ or MDIO.

An additional management infrastructure is envisioned with the additional paths labeled Path 2 on the right of Figure 5. This Optical Transport Layer management can handle advanced functionalities of smart pluggable modules not traditionally designed into or foreseen for router hosts. Multiple options for implementing the communication path are shown, illustrating the different possibilities to establish the required communication channel for this management architecture. In general, the back-office OSS communicates with the Optical Layer Management through the latter's NBI, and optical layer parameters are communicated to the host either through the DCN via the dedicated DCN port (as shown in Figure 5, Path 2D or Path 2F) or via in-band communication through the data path (Figure 5, Path 2E or Path 2G). The actual implementation path is strongly dependent on the type of host and its capabilities. When messages from the optical transport controller and destined for the smart pluggable module are

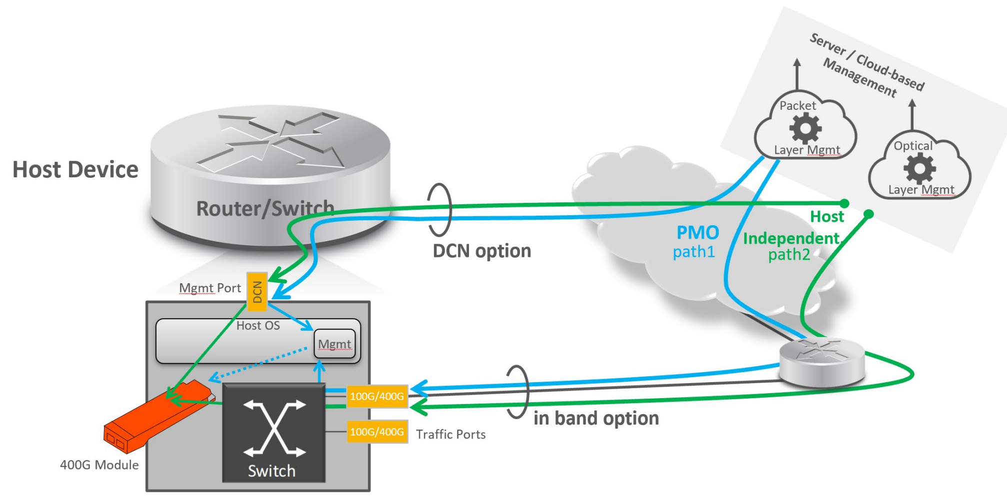


**Figure 6. Host independent management of smart optical modules.**

received by the host, they are forwarded to the module. These messages can be forwarded through any communication interface or forwarding technique available between the host and the module, including an E-SGMII interface (either a vendor-specific or standardized E-SGMII; see Figure 5, Path 2D and Path 2E) or over the host data path (SerDes) interface (Figure 5, Path 2F and 2G).[4] One possible implementation uses an L2 interface on each smart module, which would increase the number of L2 interfaces that the host must accommodate. This may impact or be affected by the existing host architecture. Depending on the deployment scenario and specific network and host implementation, the host operating system could be bypassed completely, e.g., by using an MVLAN on the data path, (Figure 5, Path 2G). The path option selected depends on the operational needs of the deployed network or operator and the specific implementation capabilities of the host, which are beyond the scope of this white paper.

This alternate or second path ultimately enables host independent management of advanced functionalities not known or implemented by the host. This host independent path enables a clear separation of control functions to the virtualized transponder provided by the smart optical module. The virtualized transponder provides the optical transport functionality that was previously provided by a separate stand-alone transponder chassis. The host independent path, when combined with the PMO Path 1 to the module, allows “Dual Management” of the module, with the host retaining control over all traditional host-side aspects, such as bringing up the module upon installation, managing the module SerDes and lane assignments, monitoring alarm registers, etc. The host independent path enables the optical transport controller to manage the virtualized transponder, setting wavelength assignment, power levels, transmission modes, etc.

[4] While an E-SGMII is shown as a management communication interface to the module, nothing precludes the use of an $I^2C$ interface and Command Data Block (CDB) messages to pass management messages to the smart optical module.

# 7 Separation of Packet and Virtualized Transponder Functions

The following subsections illustrate the separation of responsibilities across the two controllers.

## 7.1 Host Management with Present Mode of Operation (Path 1)

The host management brings up the module upon installation and manages the module SerDes and client lane assignments to define the interfaces (e.g., Ethernet interfaces). Upon insertion of the module to the host, the module advertises SerDes configurations and speeds that it offers on its MSA host interface. The host controls this configuration and assigns logical lanes to the physical SerDes lanes. The host also monitors MSA defined alarm registers. PMO Path 1 (in Figure 5 and Figure 6) controls the attributes that define the interface between the host and the smart module. With respect to separation of control, these functions are only controlled via the traditional PMO Path 1. The Optical Layer Management is made aware of these attributes by the smart module but does not control or "write" to these register attributes.

## 7.2 Host Independent Management (Path 2)

The Optical Layer Management uses Host Independent Management Path 2 (in Figure 5 and Figure 6) to perform the following functions: module discovery and inventory, host/module association, network topology discovery, bandwidth allocation, performance and alarm monitoring, and advanced diagnostics and troubleshooting of the optical transport layer. Tradeoffs between modulation, symbol rate, and reach are handled by the Optical Layer Management. Just as the first path controls the attributes that define the interface between the host and the smart optical module, the second path controls the optical attributes that define the interface between the smart optical module and the optical line system. Path 2 controls the virtualized transponder functions on the transport side of the virtualized demarcation points shown in Figure 3.

## 7.3 Host Independent Connectivity and Host Augmented Connectivity

Once initialized, the smart optical module communicates with the Optical Layer Management and the second path is established. This path can be established in a manner that is completely independent of the host, for example through a Management VLAN (MVLAN) using the data path, as illustrated by Path 2E or Path 2G in Figure 5.[5] Alternatively, the path can be established without relying on the establishment of MVLANs where the host itself provides augmented connectivity support. Examples are to establish ethernet/IP connectivity over an E-SGMII interface between the host and the smart module or an application (the Agent in Figure 5) that is dedicated to providing communication between the DCN port and the module. Such an application provides connectivity but is otherwise unaware of the DWDM specific content. The introduction of Host Augmented Connectivity as illustrated by Path 2D and Path 2F in Figure 5 can ease the operational tasks and mitigate security concerns. The methods to define, develop and troubleshoot interoperability across pluggable and host vendors are beyond the scope of this whitepaper.

[5] Use of an MVLAN and the data path to reach the module implies that the smart optical module has some L2 processing capability, though support for a full L2 stack is not required.

## 8 Characteristics of the Smart Pluggable Module

For the discussion here, we have assumed the module is QSFP-DD format. However, this Smart Pluggable Module paradigm is independent of the module form factor. The proposed paradigm is applicable to any module format including OSFP, QSFP-28 and CFP2 modules.

The module register map and capability advertisement will be consistent with CMIS [5] and C-CMIS [6] and communication with the host router will be through a management interface such as $I^2C$ (Two Wire Interface) or a faster E-SGMII.[6]

## 9 Summary

This white paper introduces a management control paradigm that decouples optical layer control of the smart optical module from packet layer control of the host device. This host independent control is enabled by virtualized transponders provided by Smart Modules that are separately addressable network entities. This virtualized transponder architectural model and paradigm for the management plane abstracts advanced smart module optical transport features (e.g., line transmission modes, telemetry, optical settings, etc.) from the hosting equipment enabling a clear separation of control functions. It alleviates the need for the host to implement custom management software to support these features. This proposed management architecture decouples co-development timelines enabling advanced functionalities of the smart optical modules to be managed via a separate smart optical transport controller. It introduces an alternate communication path allowing a smart controller to reside off the host to manage a smart module's advanced capabilities.

This virtualized transponder paradigm enables an operator to disaggregate packet host functions from optical functions maintaining the demarcation between the packet and optical Layers. This can facilitate rapid deployment of new features in a disaggregated environment. This has the potential to greatly simplify the disaggregation challenge of managing smart pluggable modules in a variety of host types from a variety of vendors.

The benefits offered by the paradigm presented in this white paper are not without tradeoffs; there are certain issues that must be addressed to realize such a paradigm. In some cases, there will be an increase in management traffic through the host to manage a large number of modules from various vendors; one must ensure that there are no congestion points that hinder management of the modules. Security must be addressed to ensure that only authorized management transactions are allowed and to protect the management network from denial-of-service attacks. Care must be taken to harmonize between the IP and Optical controllers and some method must be implemented to ensure that the IP controller and the Optical controller do not issue conflicting directives to the module.

While these tradeoffs require further work to resolve, this paradigm enables new host types to introduce smart modules with advanced features independently of the core host device management system (e.g., white box type devices, edge compute and data servers, 6G aggregation points, etc.). As bandwidth demands continue to increase and coherent modules migrate to the edge of access network, host independent management of smart modules can play an important role to accelerate the deployment of disaggregated networks.

[6] For a CFP2 module, communication is via MDIO and the register map is governed by the CFP MIS [7].

## 10 References

[1] D. Welch *et al.*, "Point-to-Multipoint Optical Networks Using Coherent Digital Subcarriers," *J. Light. Technol.*, vol. 39, no. 16, pp. 5232–5247, 2021

[2] TIP OOPT MUST Optical White Paper - Target Architecture: Disaggregated Open Optical Networks, Telecom Infra Project (TIP), 2021. [Online]. Available: telecominfraproject.com/oopt/

[3] MANTRA Whitepaper – IPoWDM convergent SDN architecture – Motivation, technical definition, & challenges, Telecom Infra Project (TIP), 2022. [Online]. Available: telecominfraproject.com/oopt/

[4] O-RAN Management Plane Specification 13.0, O-RAN.WG4.MP.0-R003-v13.00, 10/2023. [Online]. Available: https://orandownloadsweb.azurewebsites.net/specifications

[5] Implementation Agreement (IA) Common Management Interface Specification (CMIS), Optical Internetworking Forum, OIF-CMIS-05.2, 2022. [Online]. Available: www.oiforum.com

[6] Implementation Agreement for Coherent CMIS, Optical Internetworking Forum, OIF-C-CMIS-01.2, 2022. [Online]. Available: www.oiforum.com

[7] CFP MSA Management Interface Specification, CFP MSA, Version 2.6 r06a, 2017. [Online]. Available: cfp-msa.org/documents/

## 11 Glossary

| | |
|---|---|
| AOC | Active Optical Cable |
| C-CMIS | Coherent CMIS |
| CDB | Command Data Block |
| CFP MSA | 100G Form factor Pluggable Multi-Source Agreement |
| CMIS | Common Management Interface Specification |
| DAC | Direct Attach Copper |
| DCN | Data Communications Network |
| DWDM | Dense Wavelength Division Multiplexing |
| E-SGMII | Enhanced Serial Gigabit Media Independent Interface |
| $I^2C$ | Inter-Integrated Circuit |
| IETF | Internet Engineering Task Force |
| IP | Internet Protocol |
| IPoDWDM | IP over DWDM |

| | |
|---|---|
| L2/L3 | Layer 2/Layer 3 |
| MDIO | Management Data Input/Output |
| MIS | Management Interface Specification |
| MSA | Multi Source Agreement |
| MVLAN | Management VLAN |
| NBI | Northbound Interface |
| O-OLS | Open-Optical Line System |
| OOPT | Open Optical Packet Transport |
| O-OT | Open-Optical Terminal |
| OSFP | Octal Small Form factor Pluggable |
| OSS | Operational Support System |
| OTN | Optical Transport Network |
| PM | Performance Monitoring |
| PMO | Present Method of Operation |
| QSFP | Quad Small Form factor Pluggable |
| RMON | Remote Monitoring |
| SDN | Software Defined Network |
| SerDes | Serializer/Deserializer |
| SFTP | Secure File Transfer Protocol |
| TIP | Telecom Infra Project |
| VLAN | Virtual Local Area Network |