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# THE CASE FOR OPEN LINE SYSTEMS

*Reducing Vendor Lock-in and Speeding Innovation by  
Disaggregating WDM Transport*

Taking a cue from the separation of hardware, operating systems, and applications software in IT, and more recently the separation of compute, storage, and networking in data centers, the trend toward disaggregation and openness is starting to impact the broader communications equipment market. This impact is already being felt with the shift to SDN, disaggregating the control plane from the forwarding plane, and the shift to NFV, disaggregating network hardware from software functions. In terms of WDM transport, disaggregation is coming in the form of open line systems.

# WHAT IS AN OPEN LINE SYSTEM?

## TRADITIONAL INTEGRATED WDM SYSTEMS

Traditional networks, as shown in Figure 1, typically consist of an integrated WDM system that includes transponders/muxponders and the WDM line system. The WDM line system can consist of filters for multiplexing and demultiplexing the WDM channels, Wavelength Selective Switches (WSSs) for ROADMs, amplifiers, and other functions such as power monitoring, OSC, and OTDR. The integrated WDM system is provided by a single vendor and managed by a proprietary network management system (NMS). Routing and transport switching are provided by dedicated platforms each with its own NMS, though more recently converged packet optical platforms have integrated transport switching together with the transponder/muxponder function and the WDM line system.

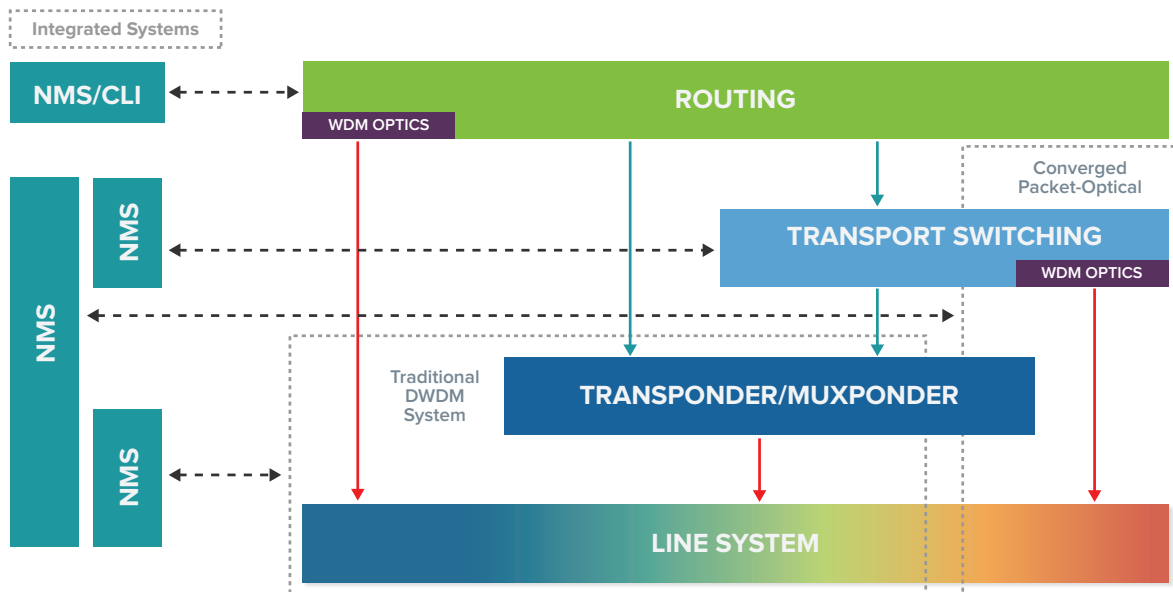


FIGURE 1 – Traditional Integrated WDM

## OPEN LINE SYSTEMS

Disaggregation separates integrated systems into functional blocks, enabling the network operator to select best-in-class products for each functional block. In the context of WDM transport, this means disaggregating a traditional integrated WDM system into a separate open line system (OLS) and a separate transponder/muxponder platform. In terms of converged packet optical, this could mean two functional blocks, the OLS and transport switching with integrated WDM, or it could mean three functional blocks, OLS, transponder/muxponder, and switching. Additional possible functional block groupings, as shown in Figure 2, include routing, routing with WDM interface optics, and switching/routing with WDM interface optics.

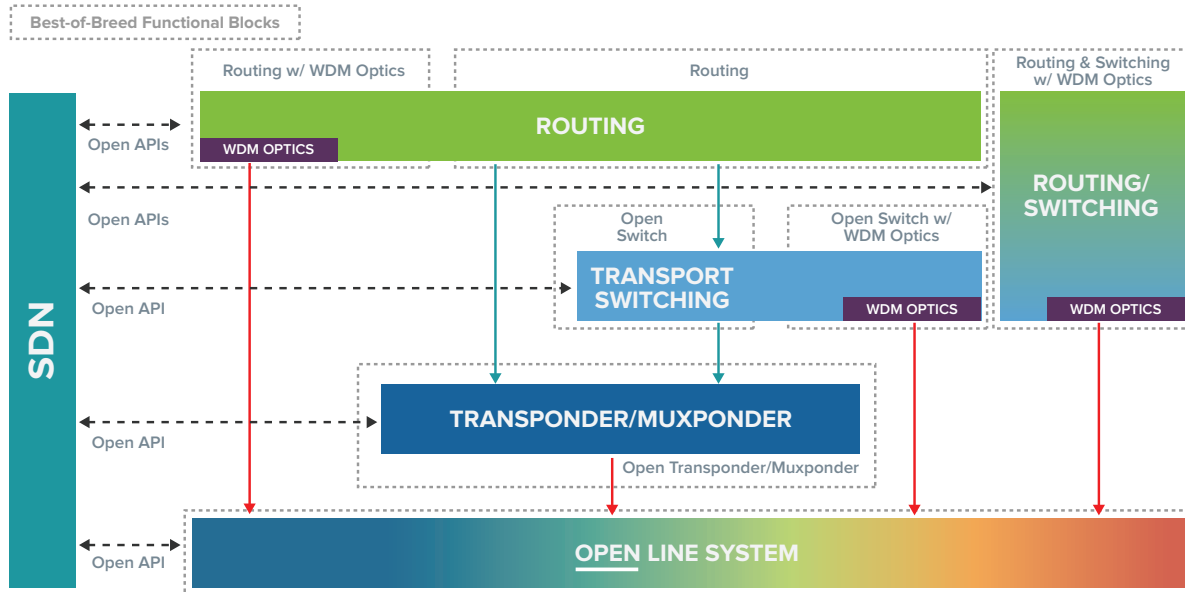


FIGURE 2 – Open Line System Approach

## DISAGGREGATION AND INTEGRATION

Disaggregation and integration are not mutually exclusive. Within any of these functional blocks the goal is to reduce cost, footprint, and power consumption with tight integration, leveraging technologies such as photonic integration, including silicon photonics, and traditional silicon integration for the electronics. The grouping of functions within these functional blocks will depend on factors such as innovation, depreciation and renewal cycles, and capacity and scalability requirements.

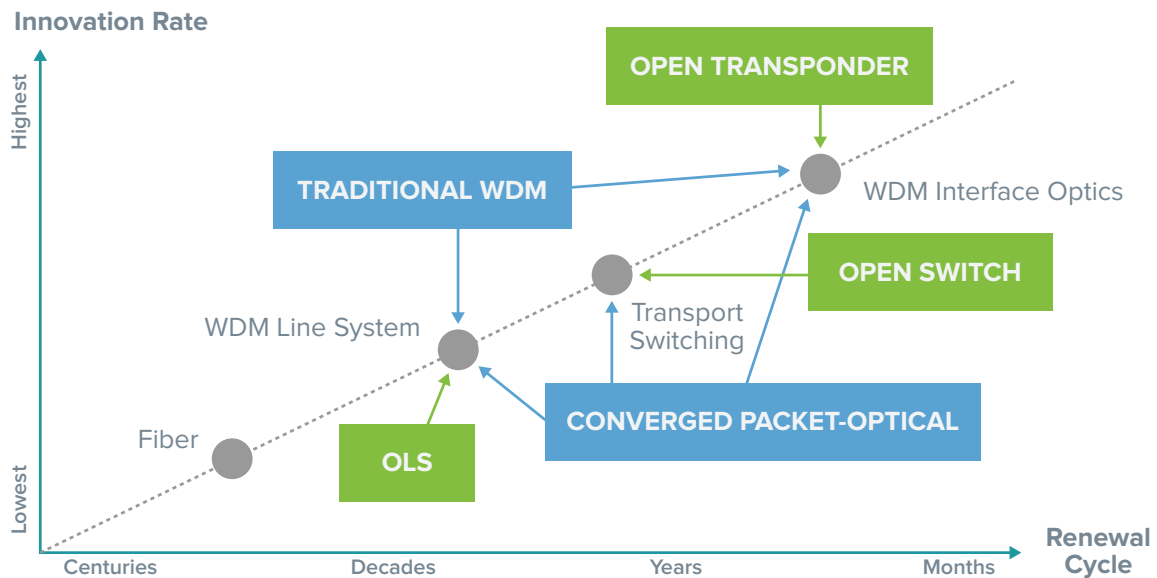


FIGURE 3 – Innovation Rate vs. Renewal Cycle

As shown in Figure 3, innovation rates and depreciation/renewal cycles tend to be strongly correlated with a high innovation rate leading to a high rate of depreciation and a shorter renewal cycle and vice versa. While WDM interface optics have a high rate of innovation, the pace of change in WDM line system technologies such as amplifiers and WSSs tends to be slower with transport switching falling somewhere in between. Innovation in the optical fiber is much slower with renewal cycles of decades if not centuries. Grouping functions by their innovation rate enables each functional block to be renewed at its own pace independent of the renewal cycles of the other functional blocks.

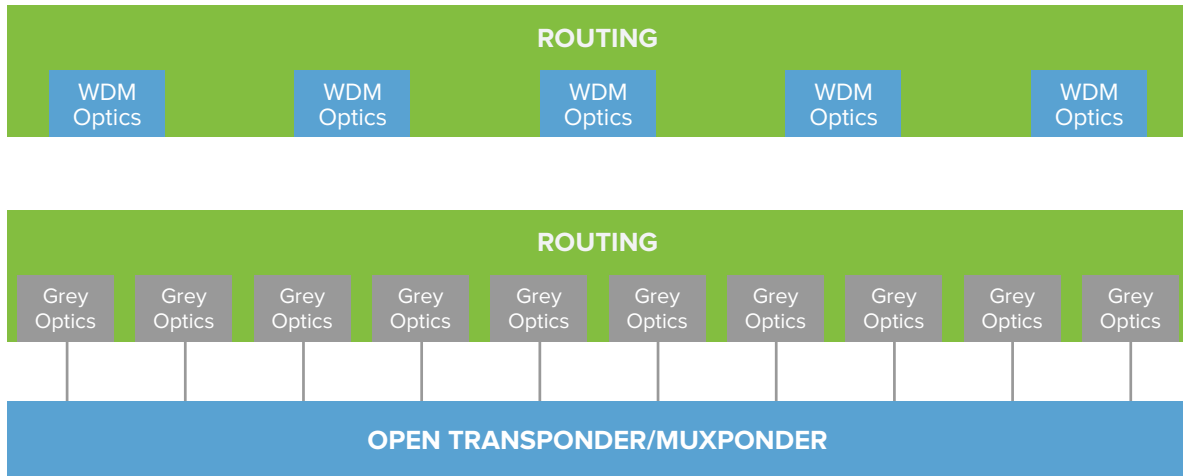


FIGURE 4 – Router WDM Optics Integration vs. Density/Capacity

An example of capacity/scalability requirements driving functional blocks is router capacity and the decision of whether or not to integrate the WDM interface optics function. The components for WDM interface optics take up space and consume power. Integrating these on the router line card will reduce its port density. If capacity requirements are high, then separating out the WDM interface optics into an external transponder/muxponder will enable the maximum interface density in the router; while if capacity requirements are more modest, then the benefits of integrating the transponder function may outweigh the loss in density.

### OPENNESS

Aside from disaggregation into functional blocks, what differentiates the OLS approach from traditional approaches is openness. Openness involves the ability to support different vendors for each functional block/layer and even interoperability between multiple vendors for the same functional block/layer. Openness also relates to open APIs enabling SDN to provide end-to-end management and control. However, the OLS approach typically requires the network operator to take more responsibility for the network software, including management, control, and planning, especially in multi-vendor scenarios.

## MULTIPLE VENDORS

Having disaggregated the WDM system into functional blocks, the next thing to consider is the number of vendors for each functional block and the network software, as shown in Figure 5. If we consider a WDM system that has been disaggregated into an OLS and a traffic bearing functional block (transponder/muxponder and/or transport switching) with an SDN control layer, then one approach could be to use different network elements for the OLS and the traffic block but with the same vendor providing both network elements and the SDN software. A second approach is a variation of the first approach using the same vendor for the OLS and traffic block but with in-house or third-party SDN.

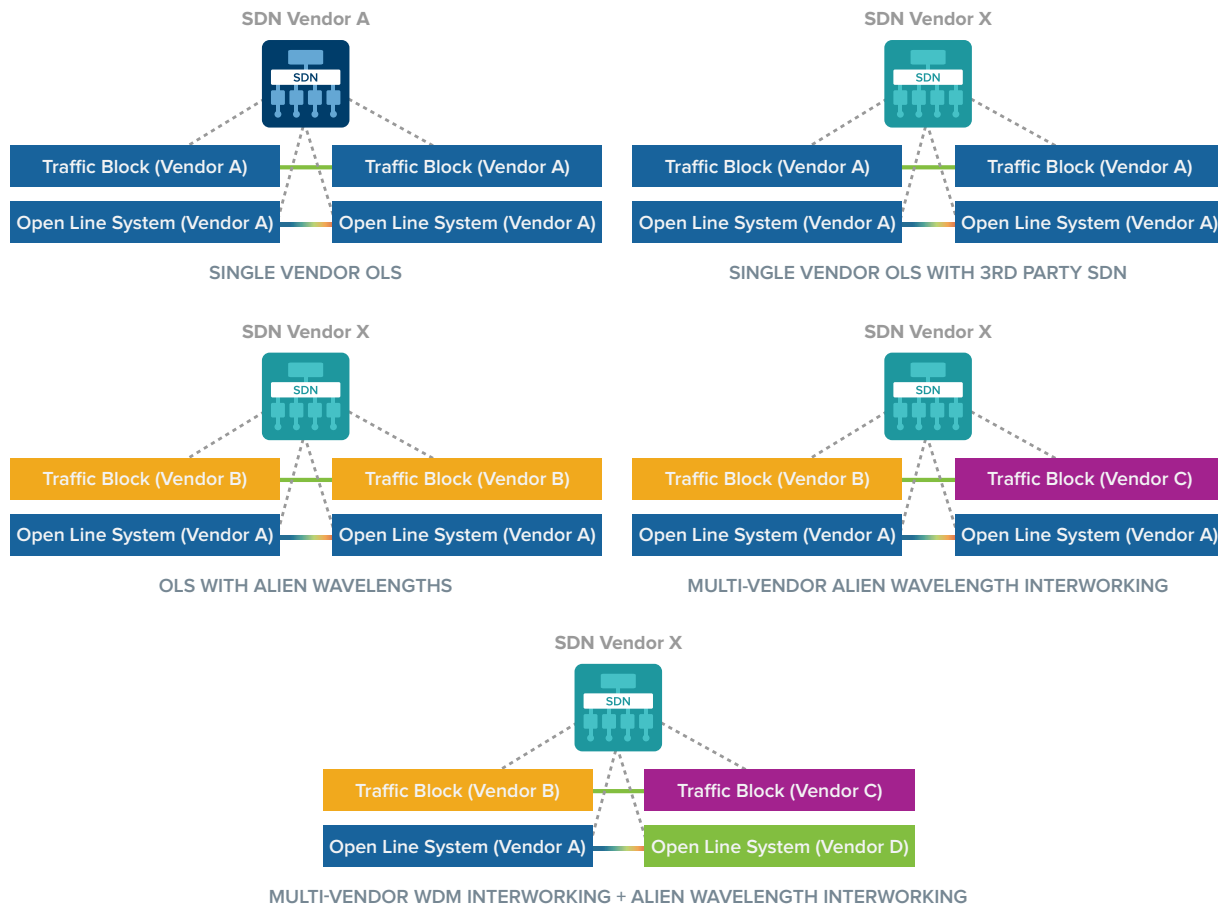


FIGURE 5 – Multi-vendor OLS Scenarios

A third approach is to use one vendor for the OLS and a second vendor for the traffic block. In fact, this approach with alien muxponders and third-party SDN is already being deployed for data center interconnect (DCI). A fourth approach is to use a single vendor for the OLS where interoperability is most challenging, while using two or more vendors at the traffic bearing block with interoperability between WDM interface optics enabled by using the same modulation and common forward error correction (FEC). A fifth approach encompasses using multiple vendors for each functional block with the addition of interoperability between OLSs from different vendors including the OSC and link control/power level setting.

## OPEN LINE SYSTEM BENEFITS

OLS benefits include reduced vendor lock-in resulting in competitive pricing and faster innovation, which in turn can drive lower CapEx and lower OpEx.

### REDUCED VENDOR LOCK-IN

Reducing vendor lock-in is a key attraction of the OLS approach. Despite their many benefits, traditional integrated WDM solutions lock network operators into a single vendor's solution for the lifespan of the network, which can be many years if not decades. Disaggregation and openness reduce vendor lock-in, reducing the barriers to introducing new vendors as and when needed, in accordance with the renewal cycle of each layer/functional block. New vendors with best-in-class technology for specific functional blocks can be introduced incrementally without the need for forklift upgrades, swapping out the entire optical network or building a parallel network. Reducing vendor lock-in has two primary benefits: competitive pricing and faster innovation.

### COMPETITIVE PRICING

While the initial purchasing process for a traditional WDM network is typically highly competitive, once a vendor has been selected and the network has been deployed, the bargaining power of the network operator is severely diminished with the incumbent vendor in a much stronger position regarding future pricing negotiations. By reducing vendor lock-in and enabling other vendors to compete for incremental upgrades based on the renewal cycle of each functional block, competitive pricing pressures can be maintained throughout the lifecycle of the network. Furthermore, by lowering barriers to entry, innovative smaller vendors can also compete without having to be able to offer a complete solution including the NMS. An increased number of competitors will also have a positive impact on the ability of network operators to drive attractive pricing.

### FASTER INNOVATION

Innovation is the key driver for lower cost per bit, increased reach and capacity, and lower space and power in optical networking. With a traditional WDM solution, the network is constrained by the innovation capabilities of the single selected vendor and its suppliers. The OLS approach enables network operators to align the upgrade of each functional block to its renewal cycle while leveraging the innovation capabilities of the entire industry. As discussed previously, with reduced barriers to entry, new and smaller vendors will now be able to compete bringing new innovation capabilities to the market. Finally, with openness simplifying the integration of new technologies into the IT/OSS environment, new technologies can be adopted more quickly and with lower cost and less disruption.

### LOWER CAPEX

The OLS approach can enable lower CapEx in a number of ways. The first is through competitive pricing throughout the network lifecycle as discussed previously. The second way is through innovation. Innovation is the primary driver of lower costs per bit in optical networking. Innovation is also the key driver for improved reach and capacity/spectral efficiency.

Extended reach reduces the cost of OEO regens and increased capacity/spectral efficiency extends the life of the network and reduces the cost of upgrading optical layer assets.

## LOWER OPEX

In addition to lower CapEx, the OLS approach can decrease operational costs. One of the benefits of faster innovation is reduced footprint and lower power consumption. In addition, openness, though not requiring disaggregation but often going hand-in-hand with it, can substantially reduce the cost of IT integration. Anecdotal reports suggest the potential cost reduction is up to 90%.

## KEY ENABLERS FOR OPEN LINE SYSTEMS

### SDN AND OPEN APIS

Traditionally it has been far simpler to manage a single integrated product and to integrate it into the operator's OSS environment. However, the desire to lower the cost of IT/OSS integration and the need for greater agility have driven the rapid development of SDN. With its open APIs and the ability of YANG models to abstract the capabilities of the disaggregated functional blocks, SDN removes one of the key barriers to disaggregation and to multi-vendor networks.

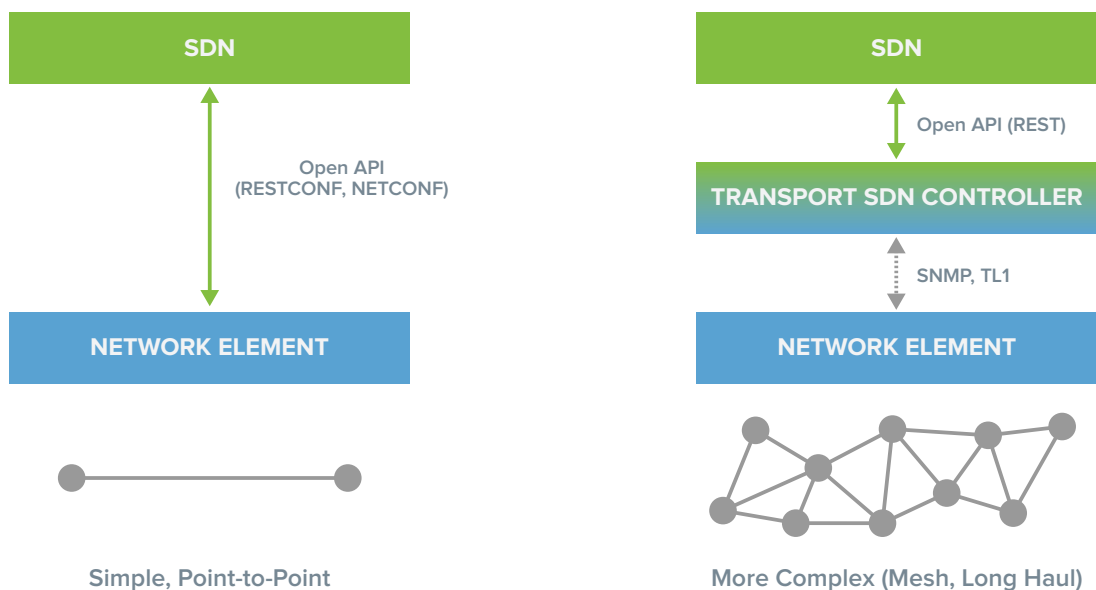


FIGURE 6 – SDN and Open APIs

As shown in Figure 6, for simple point-to-point networks with a small number of nodes, the open API (i.e., RESTCONF or NETCONF) is likely to be directly on the network element. For more complex networks such as a meshed metro or a long haul network, a transport controller is likely to be required to provide a further level of abstraction and to provide the open API (i.e., REST). Furthermore, this abstraction enables the network operator to benefit from vendor-specific innovations without the need for detailed knowledge of how these innovations work.

## PER CHANNEL POWER MONITORING

A key requirement for disaggregation of the WDM line system and the WDM interface optics is the ability to monitor alien wavelengths. Per channel power monitoring is now widely available in WDM systems and gives the WDM line system visibility to wavelengths that are coming from third-party interfaces. With this visibility, the WDM line system can then set the power levels using the WSS or EVOAs to perform the attenuation according to the rules of the WDM line system's link control algorithms. However, as coherent technology evolves with higher baud rates and new modulation schemes, per channel power monitoring will need to keep pace, perhaps providing a short-term advantage for integrated systems or single vendor OLS solutions.

## IMPROVED COHERENT 100G PERFORMANCE

Optical performance has historically been another barrier to the adoption of disaggregation and a key argument against alien wavelengths, especially in long haul networks. And while integrated systems might have a performance advantage for wavelengths above 100G, improvements in the performance of coherent 100G make it a viable option for disaggregation, even in long haul networks. For example, if the maximum reach of an integrated 100G solution was 3,000 km while a disaggregated solution was 2,000 km, and the operator needed the wavelength to go 2,800 km, then the integrated solution would have a clear advantage. However, if technology improvements increased the integrated solution to 5,000 km and the disaggregated solution to 4,000 km, then disaggregation becomes a viable option.

## INTEROPERABILITY SPECIFICATIONS

Interoperability specifications are important enablers for OLS adoption and are being driven by a number of industry initiatives including the Open ROADM Multi-Source Agreement (MSA) led by AT&T and the Open Optical Packet Transport project within the Telecom Infra Project (TIP) led by Facebook. Focused on the metro, the Open ROADM MSA defines interoperability specifications for ROADMs, transponders, and pluggable optics with specifications for optical interoperability as well as YANG data models. The TIP Open Optical Packet Transport project is focused on DWDM open packet transport architectures enabling innovation and avoiding lock-in.

In addition to these initiatives, FEC interoperability enables WDM interface optics from different vendors at each end of individual wavelengths. DWDM interface interoperability was first standardized for 10G/OTU2 in the G.698.2 "black link" standard in 2009. For coherent 100G, interoperability is enabled by staircase FEC, a royalty-free 7% hard decision FEC providing a 9.38dB net coding gain that is widely available from DSP, framer, and CFP-DCO vendors. Standardization efforts include ITU-T Q11/15 adding OTU4 Staircase FEC to the G.709 standard and ITU-T Q6/15 adding 100G/OTU4 to the G.698.2 standard. However, the 9.38dB net coding gain is significantly less than best-in-class proprietary FECs, which are typically closer to 12dB, so interoperability comes at a cost in terms of reach/capacity, and interoperable FEC is likely to be restricted to metro applications. Interoperability also comes at a cost in terms of the ability to benefit from vendor-specific innovations.



## OPEN LINE SYSTEM USE CASES

### METRO POINT-TO-POINT DCI

Point-to-point DCI over metro distances is an obvious starting point for OLS. Internet Content Providers (ICPs), with their focus on innovation and scaling bandwidth cost effectively, have been among the key proponents of the OLS approach. SDN adoption is also highest in data center environments. This use case requires compact products that meet data center requirements such as AC power, front-to-back airflow, and 600 mm depth. Given the simplicity of point-to-point DCI, YANG model-based open APIs such as NETCONF and RESTCONF can be supported directly on the network element without the need for an intermediate controller providing abstraction. Given its point-to-point nature, a single vendor is likely to provide both ends of the OLS, while a different vendor, or vendors, can provide the traffic bearing functional blocks, also with data center form factors.

### METRO MESH

Unlike metro point-to-point DCI, this use case comprises rings and mesh topologies with a much larger number of nodes. As described previously, the added complexity of a metro mesh/ring topology with more than a few nodes is likely to require a transport SDN controller to provide a layer of abstraction with open APIs on the controller rather than the network element itself. Relative to long haul, with more limited reach requirements, interoperable FEC and ROADM degree interoperability become options in the metro, enabling multi-vendor scenarios both within functional blocks/layers as well as between functional blocks/layers.

### LONG HAUL

Long haul differs from the metro use cases in terms of the optical performance required to support much longer distances. This requirement for performance cannot be met with lowest common denominator technology required for interoperability and requires vendor-specific innovations to achieve the maximum performance. In terms of WDM optical interface technology, these innovations include enhanced FEC, spectral shaping, impairment compensation, novel modulation, and increased baud rates. WDM line system innovations that impact reach include the link control and amplification technology. For these reasons, long haul networks are likely to maintain a single vendor for the OLS layer, and while capable of supporting multiple vendors at the traffic bearing layers, equipment at both ends of each wavelength is likely to be from the same vendor. Like metro mesh, given the complexities of optimizing performance in a long haul network, a transport SDN controller is likely to be required for abstraction.

### SUBMARINE

The use of different vendors for the traffic bearing functional block, typically referred to as Submarine Line Termination Equipment (SLTE), and WDM line system, typically referred to as “wet plant,” is not new in submarine. However, what is new is that while in the past submarine networks were initially deployed with a single vendor and then evolved to multi-vendor systems with new vendors introduced for SLTE, new submarine systems are starting to be deployed with different vendors for the SLTE and wet plant from day one.

Wet plant and SLTE technology evolve at very different rates and the wet plant must be selected and deployed a long time before the SLTE. This approach lets the submarine cable operators select the best SLTE at the time it will be deployed rather than at the beginning of the wet plant deployment cycle.

## OPEN LINE SYSTEMS VS. TRADITIONAL INTEGRATED APPROACHES

While the OLS approach offers many potential advantages, traditional integrated approaches including converged packet optical also have advantages.

	<i>Open Line System Approach</i>	<i>Traditional Integrated Approaches</i>
<i>Pricing Competition</i>	<ul style="list-style-type: none"> <li>▪ Reduced vendor lock-in = competitive pricing throughout the network lifecycle</li> <li>▪ Lower barriers to entry = more competitors</li> </ul>	<ul style="list-style-type: none"> <li>▪ Intense pricing competition at the beginning of the network lifecycle</li> </ul>
<i>Innovation Speed</i>	<ul style="list-style-type: none"> <li>▪ Reduced vendor lock-in = industry-wide innovation</li> <li>▪ Better align upgrades to technology renewal cycles</li> <li>▪ Lower barriers = innovative new entrants</li> </ul>	<ul style="list-style-type: none"> <li>▪ Best approach for innovations that require tight coupling between line system and interface optics</li> </ul>
<i>Reach/Capacity</i>	<ul style="list-style-type: none"> <li>▪ Innovation is the primary driver for reach/capacity</li> <li>▪ Ability to select best-in-class for each functional block</li> </ul>	<ul style="list-style-type: none"> <li>▪ More accurate planning</li> <li>▪ Possibility to tune performance across line system and interface optics</li> </ul>
<i>Operational Costs</i>	<ul style="list-style-type: none"> <li>▪ Innovation is the primary driver for space/power</li> </ul>	<ul style="list-style-type: none"> <li>▪ Simplified OSS integration in non-SDN environments</li> <li>▪ Guaranteed interoperability</li> <li>▪ Simplified troubleshooting/support</li> <li>▪ Fewer NEs to install, manage, maintain</li> <li>▪ Fewer shelves = reduced space/power</li> </ul>
<i>High Availability</i>	<ul style="list-style-type: none"> <li>▪ Fewer complex failure scenarios relative to more complex chassis-based solutions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Guaranteed interoperability</li> <li>▪ Simplified troubleshooting</li> </ul>

TABLE 1 – OLS Advantages vs. Advantages of Integrated Approaches

### PRICING COMPETITION

The reduced vendor lock-in of the OLS approach enables competitive pricing throughout the network lifecycle while reduced barriers to entry may enable more competitors. This compares to traditional approaches, which benefit from intense price competition when the optical vendor is first selected but with more muted price competition thereafter.

## **INNOVATION SPEED**

The OLS approach enables network operators to leverage the innovation capabilities of the entire industry and fully benefit from the innovation rate of each functional block/layer through reduced vendor lock-in. Open APIs also simplify the task of integrating new technologies, though this can also apply to traditional approaches that provide open APIs. One area where traditional integrated approaches may have an innovation advantage is where there needs to be a tight coupling between innovations at different layers. An example of this is where an innovative new modulation scheme in the WDM interface optics requires enhanced per channel power monitoring or optical link control algorithms in the WDM line system.

## **REACH/CAPACITY**

Innovation is the primary long-term driver of improved reach/capacity. Advantages of the OLS approach include faster innovation and the ability to select best-in-class products for each functional block independently. The advantages of traditional integrated approaches include more accurate end-to-end planning with both the WDM interface optics and WDM line system coming from the same vendor. However, this planning advantage could be neutralized with a single vendor OLS solution or with planning that integrates real-time optical performance measurement as is the case with Coriant Aware™ Technology (see the Coriant white paper *Evolving the Awareness of Optical Networks* for details). An additional advantage for integrated approaches is the possibility to fine-tune system parameters such as the launch power across both the WDM line system and WDM interface optics to optimize the end-to-end performance.

## **OPERATIONAL COSTS**

The faster innovation of the OLS approach is likely to give it an advantage in terms of space and power relative to integrated approaches. Integrated approaches on the other hand will have operational cost advantages in terms of guaranteed interoperability and simplified troubleshooting and support with a single vendor to hold accountable for any problems. Both the OLS approach and integrated systems with SDN support can reduce the cost of IT/OSS integration. However, in environments that have not yet adopted SDN, incorporating a single integrated platform will be easier and more cost-effective. Additional potential OpEx advantages for traditional integrated approaches include fewer NEs to install, manage, and maintain along with fewer shelves, which could potentially save space and power especially with converged packet optical platforms.

## **HIGH AVAILABILITY**

One final topic to consider is network and service availability. Here integrated systems have advantages in terms of guaranteed interoperability and simplified troubleshooting/support as discussed previously. However, some proponents of the OLS approach make the argument that they have fewer complex failure modes relative to more complex chassis-based systems.

## OLS MIGRATION STRATEGIES

There are a number of strategies open to operators who want to migrate to multi-vendor OLS at their own pace or at least maintain the option to do so when the time is right.

### DEPLOY AN OLS-READY INTEGRATED PLATFORM

For many operators a traditional WDM solution or a converged packet optical platform will be the best option, at least in the short-to-medium term. However, it is important to select a solution that can evolve to support OLS approaches in the future. Key features to look for include:

- Per channel power monitoring and the ability to support third-party interfaces without the need for additional hardware
- Optical link control (laser safety, channel power leveling, tilt control, etc.) that can support third-party interfaces
- Optical layer resilience options with support for third-party interfaces
- Open APIs, either directly on the NE for simple point-to-point applications or via a transport SDN controller for mesh/long haul
- Support for third-party interfaces in WDM planning and commissioning

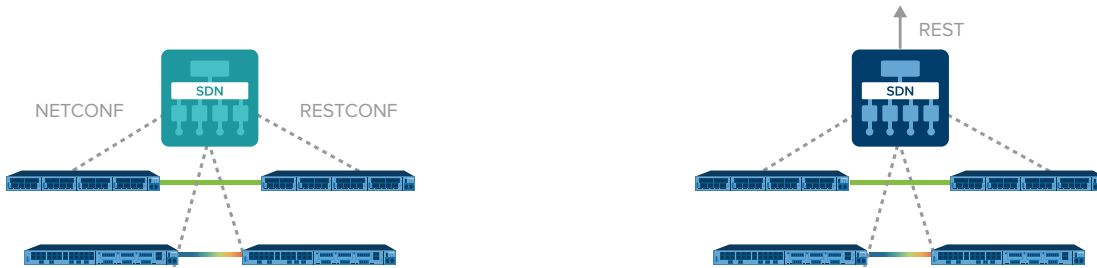
### DEPLOY DISAGGREGATED MUXPONDERS OVER AN EXISTING LINE SYSTEM

Coherent optical technology has evolved rapidly since its introduction in the last decade. Reach and spectral efficiency have increased significantly. Density and power consumption have also improved considerably, and cost per bit declines have been rapid. Network operators who selected their optical vendor several years ago face a number of challenges. The prices they are currently paying based on the negotiated contract may no longer be competitive while performance may not be best-in-class. A simple solution to these problems of vendor lock-in, stale pricing, and sub-optimal technology is to introduce optimized solutions such as the Coriant Groove™ G30 DCI Platform Muxponder configuration delivering spectrally efficient coherent transport over the existing DWDM line system with the potential for dramatic savings in cost, power, and footprint.

### DEPLOY A SINGLE VENDOR OLS SOLUTION

OLS approaches with multiple vendors create challenges for interoperability, troubleshooting and support, planning, and integration into non-SDN OSS environments. Multi-vendor OLS also requires the network operator to take more responsibility for the management, control, and planning software. Initially deploying both the OLS and traffic bearing functional blocks from a single vendor can provide many of the benefits of the OLS approach together with many of the benefits of a traditional integrated solution. Examples of how Coriant can provide a single vendor OLS solution with optimized products for the OLS and traffic bearing functional blocks, together with the option of the Coriant Transcend™ SDN Solution, are shown in Figure 7.

### METRO POINT-TO-POINT DCI



### METRO MESH



### LONG HAUL

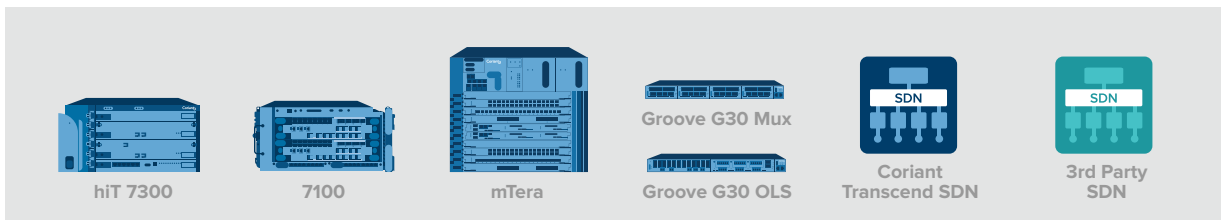


FIGURE 7 – Coriant Single Vendor OLS Examples

For metro point-to-point DCI, the 1RU Groove G30 OLS configuration provides a high-density, modular solution with plug-and-play support for both coherent and direct detect (i.e., PAM4) wavelengths. Muxponder functionality can be provided by the 1RU Groove G30 Muxponder configuration. SDN options include leveraging the Groove G30 RESTCONF and NETCONF open APIs to interface directly with third-party SDN or leveraging Coriant Transcend™ SDN for abstraction and a REST-based open API.

For metro mesh, the 5RU Coriant® 7100 Nano™ Packet Optical Transport Platform offers a compact ROADM-based OLS, with additional options provided by the Coriant® Pluggable Optical Layer in either the 7100 Nano or 2RU Coriant® 7100 Pico™ Packet Optical Transport Platform. Options for the traffic blocks include the Groove G30 Muxponder and the Coriant® mTera® Universal Transport Platform (UTP). The mTera UTP provides multi-terabit universal switching of packet, OTN, and/or SONET/SDH with integrated WDM interface optics, leveraging the same Coriant CloudWave™ Optics technology as the Groove G30 Muxponder. Coriant Transcend™ SDN provides abstraction and a REST-based open API.

For long haul, the Coriant® hiT 7300 Multi-Haul Transport Platform with its optimized EDFA and Raman amplifiers, advanced optical link control, and flexi-grid ROADM capabilities provides an ideal OLS, with shelf options including the 4RU data center-optimized 7300 DCI shelf. As with metro mesh, options for the traffic-bearing functional blocks include the Groove G30 Muxponder and mTera UTP, with Coriant Transcend™ SDN providing abstraction and a REST-based open API.

## SUMMARY

The OLS approach, disaggregating WDM transport into best-in-class functional blocks, with open APIs enabling end-to-end SDN management and control, promises to reduce vendor lock-in and speed innovation while enabling competitive pricing throughout the network lifecycle, leading to both lower CapEx and lower OpEx. Use cases include metro point-to-point DCI, metro mesh, long haul, and submarine with differences in terms of form factor requirements, possible multi-vendor scenarios, and the need for SDN abstraction. However, traditional integrated approaches also have their advantages and many operators will want to migrate to multi-vendor OLS at their own pace. Options for doing so include selecting OLS-ready integrated platforms, introducing best-in-class muxponder platforms over the existing WDM line system, and deploying a single vendor OLS solution.

## ABOUT CORIANT

Coriant develops innovative and purpose-built networking solutions for a fast-changing and cloud-enabled business world. The Coriant portfolio of SDN-enabled, edge-to-core transport solutions enables network operators to reduce operational complexity, improve utilization of multi-layer network resources, and create new revenue-generating services optimized for the evolving demands of business and consumer applications, including video, hyperscale cloud, IoT, and mobile broadband.

Coriant serves leading network operators in over 100 countries, including mobile and fixed line service providers, content providers, cloud and data center operators, cable MSOs, large enterprises, government agencies, financial institutions, and utility companies. With hundreds of thousands of networking systems deployed worldwide, Coriant solutions serve as the resilient foundation for billions of dollars in end-user service revenue. Coriant was founded upon the powerful combination of Nokia Siemens Networks (NSN) Optical Networks, Tellabs, and Sycamore Networks – a distinguished heritage of over 35 years of technology innovation.

Now fully integrated and with seasoned executive leadership at the helm, Coriant is setting the pace of innovation from network access to the optical core with best-in-class networking solutions, including the Coriant Hyperscale Carrier Architecture™, Coriant Light IP™, Coriant CloudWave™ Optics, the Coriant Groove™ G30 DCI Platform, and the Coriant® Pluggable Optical Layer.

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