Open Optical Networks

A practical guide for open line adoption for CSPs

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Table of Contents

Executive summary

The state of open optical networks

Deploying the latest coherent DWDM transmission technology over a Communication Service Provider's (CSPs) optical line system will yield immediate performance, cost, space, and power benefits. The industry has recognised this to be true for networks, and momentum is building in this direction; the subsea market has moved en masse to third-party transmission over incumbent optical line systems. 400G ZR and ZR+ as inherent open solutions are also garnering industry traction and in the case of ZR, significant deployment volumes.

The benefits are clear, but what is the cost? The cost of integration efforts is the capital and resources required to shift to a new Transport SDN environment, designed for multi-vendor management and control. While the immediate deployment of a third DWDM transmission will yield immediate benefits, shifting to a true Transport SDN environment will unlock further operational efficiencies and savings.

To date, the industry has actively progressed on standards and multi-source agreements (MSAs), having selected the Internet Engineering Task Force (IETF) Abstraction and Control of Transport Networks (ACTN) multi-layer, multi-vendor framework, paired with the Open Networking Foundation (ONF) Transport application-programming interface (TAPI) and OpenConfig's northbound API (NBI) for network elements. The maturity of these standards/MSA efforts substantially reduces the integration risk and cost for CSPs. The groundwork has been laid and the optical vendor community supports the new Transport SDN environment with open line systems.

Recommendations for CSPs

Deploy third-party DWDM transmission in portions of the network that sorely need an immediate upgrade. View this transition as a journey; start now and expand applications and network complexity over time, based on hands-on learning. The operational environment will catch up.

Recall the many successful use cases of third-party DWDM transmission already deployed in advance of the "perfect" operational environment. Become actively involved in standards/MSA activities. Leading CSPs are well down this path and will be poised to reap the early benefits of open and delayered networks. Negotiate with your incumbent line vendor to forgo license fees.

Omdia had the opportunity to discuss open optical network journeys with three leading CSPs: Rakuten Mobile, Windstream, and a major unattributed European CSP. Their insightful commentary provides a realistic assessment of the industry's progress on open optical networks. Excerpts from these discussions are included throughout the paper.

The promise of open optical networks

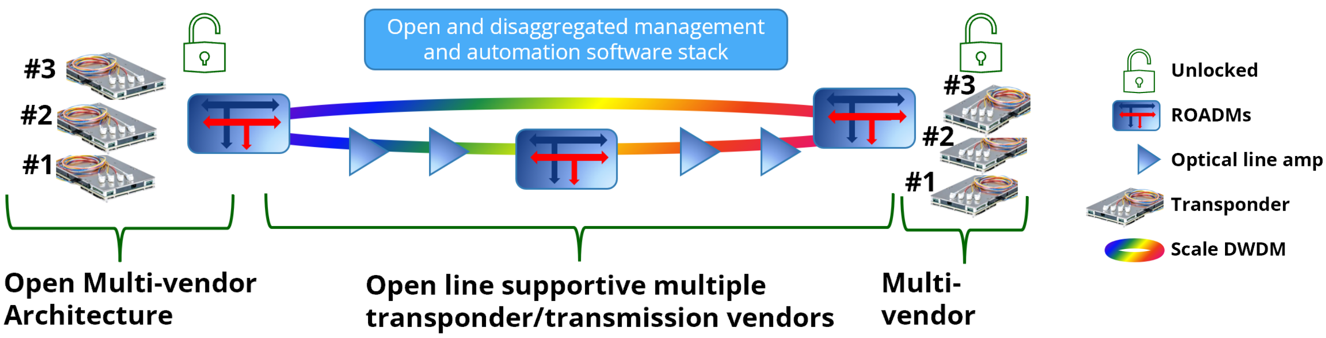
The case for disaggregated open optical networks

In the open optical network model, transmission is disaggregated from the optical line system. Additionally, the network management and automation software stack can be independent of the underpinning hardware. CSPs need to invest on future proofing their software stack and that starts with letting the legacy on its own instead of trying to integrate new technology with the old that wasn't designed for today's and future demands. Multiple alien wave optics vendors can then operate over a third-party open optical line.

The key benefits of evolving to an open optical network model are as follows:

- For the capex of alien wave optics, CSPs can reap immediate improvements in capacity, power, and footprint (physical sizes).
- CSPs can break free from lock-in to one vendor's economic model and innovation cycle.
- CSPs have future architecture choices, including enabling IP/optical convergence.
- Competition is catalysed, with multiple bid cycles over the life of the optical line.
- Supply chains are diversified to make the network more robust.

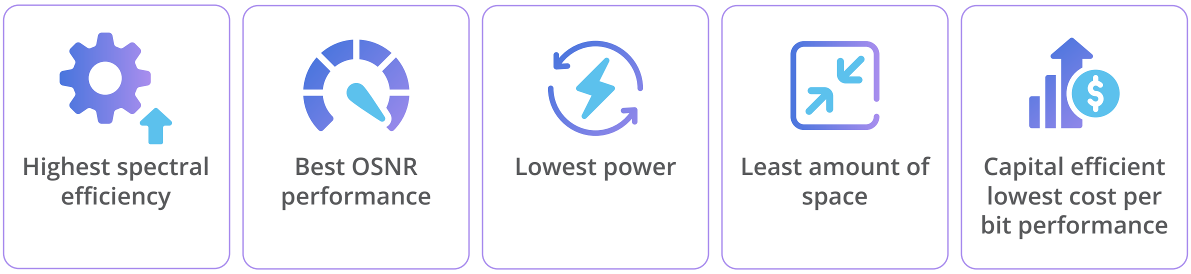
Figure 1: The open optical network architecture



Source: Omdia

Coherent transmission technology is the central differentiator in optical networks. The system vendor community competes vigorously in this segment; vendors operate on differing timelines, leading to a constant leapfrogging of product capabilities and availabilities. By introducing new transmission vendors over existing optical lines, CSPs will be able to stay at the leading edge of technology adoption, achieving the benefits shown in Figure 2:

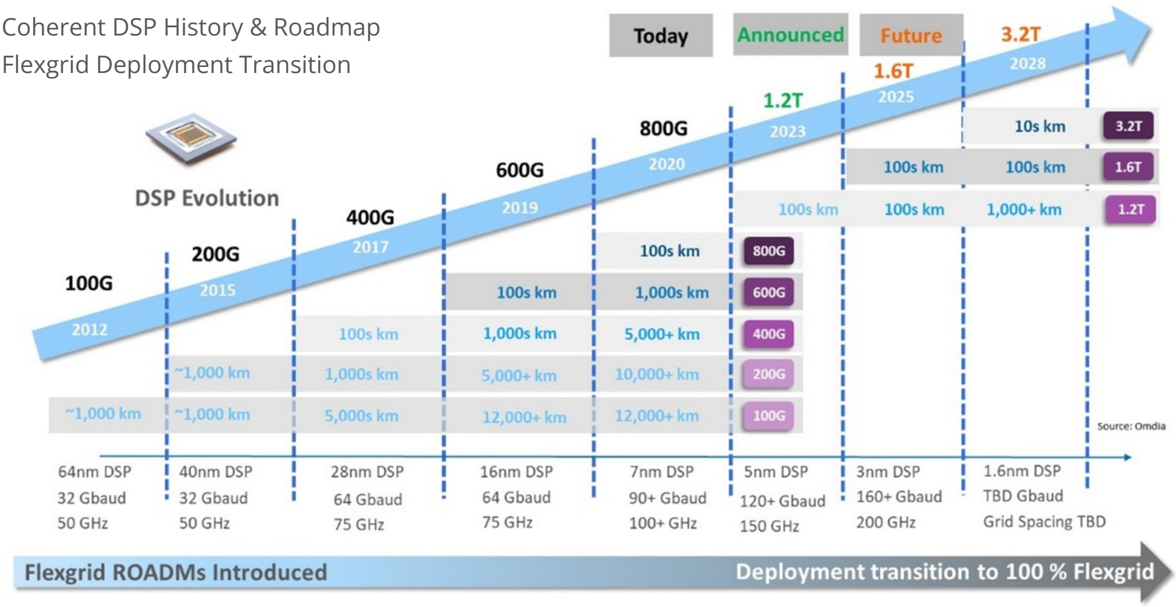
Figure 2: Key attributes of latest coherent transmission technology



Source: Omdia

Figure 3 shows the history of coherent digital signal processing (DSP). The open optical line model will allow a CSP to jump from its current technology to the latest coherent technology without having to deploy a new optical line. This model will enable tremendous leaps in performance without incurring optical line overbuilding penalties.

Figure 3: Coherent DSP history and roadmap with Flexgrid deployment transition



Source: Omdia

Flexgrid ROADMs were introduced a decade ago. However, owing to the longevity of optical lines, the industry has taken some time to transition to Flexgrid ROADMs, which are the predominant type of ROADMs shipped today. Although operational fixed grid lines are rarely decommissioned, Flexgrid ROADMs are increasingly making up a greater percentage of operationally deployed lines. Pairing the latest Flexgrid technology with the latest advances in coherent technology allows for maximum flexibility and overall system throughput.

Key building blocks for the open line model

The open line model requires several building blocks for success, including the following:

- **A standardised operational model and a Transport SDN framework**
- **Open APIs for multi-vendor network management and control**
- **Standardised data models**
- **A standards-driven framework to enable the optical validation of any optical client over an open line system. Open multi-vendor optical network planning tools**
- **New flexible grid optical lines capable of supporting transmission beyond fixed grid**
- **Fixed grid support enabled by programmable modulation formats of the latest coherent solutions**
- **Open multi-vendor optical network planning tools**
- **Supporting standards or open industry specifications for the transmission interfaces and line system. Examples: OpenROADM, OpenZR+.**

The CSP community has recognised the value of an open optical paradigm for many years. The challenge for many CSPs today is transitioning to a Transport SDN environment.

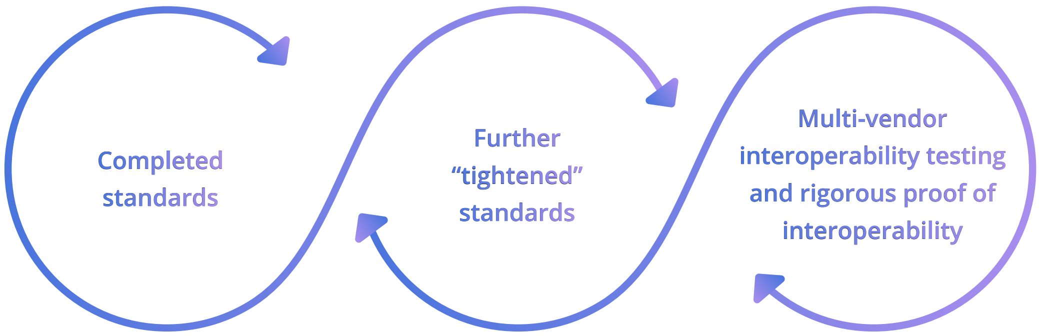
Leading CSPs are forging ahead with open optical networks. Other reluctant CSPs will follow once key building blocks have reached a penultimate level of maturity.

Successful open line use cases

Leading CSPs have advanced open optical networks

The raw network performance benefits of open optical networks are compelling, and the industry continues to build its track record of deployed open optical networks. At the same time, the industry is on journey to create a new, scalable open line operational environment. The Transport SDN operational paradigm is transitioning a from completed standards stage to a stage of rigorous multi-vendor tested interoperability.

Figure 4: Advances in Transport SDN



Source: Omdia

With the right operational precursors in place, the industry is preparing to transition to an open optical network world at commercial scale.

The subsea market and open cables

Historically, the subsea transmission market has been notoriously locked-in; it was dominated by a cozy oligopoly of suppliers, while market segment revenue languished and innovation was non-existent. Then, a few things happened—cloud service providers (cloud SPs), such as Microsoft, Google, Amazon, and Meta, began taking an interest in the subsea market to support their ambitious global networks, thus bringing coherent transmission technology mainstream. The cloud SPs are in the business of disruption, and the subsea market was ripe for disruption.

Coherent transmission from non-subsea cable vendors was deployed over pre-existing operational cables. Coherent transmission was first deployed to inject new life into old cables and provided an immediate bandwidth boost while prolonging the life of many aging cables. The market rapidly progressed from there, and cloud SPs pushed for truly “open cables,” enabling any vendor’s alien wave optics to operate over a third-party subsea optical line system.

As time went on, leading open transmission solutions shifted from offering mere bandwidth exhaust relief to the designed in transmission solution for brand new open cables. The cloud SPs’ roles in the subsea segment grew and grew, and they pushed hard for the open model. See Figure 5 for the transition from closed to open subsea transmission revenue. Of the original closed model vendors, one vendor formerly holding a 25% transmission market share, completely exited the transmission market. The remaining closed model vendors have ceded significant share to the open transmission vendor community.

Figure 5: The shift from closed to open line systems in the subsea segmenttt

Source: Omdia

Early DIY terrestrial deployment of open optical networks

The open model has found success in terrestrial markets as well, just not to a level as dramatic as quantifiably observed in the subsea segment, for a few reasons. Currently, cloud SPs make up a much larger percentage of the subsea market than the overall global terrestrial market. While major cloud providers are catalyzing much of the building of subsea networks, hundreds of CSPs also play a very strong role in terrestrial networks.

As strong proponents of open optical networks in the terrestrial market, cloud SPs have always wanted to rapidly adopt and implement the latest and most high-performing technologies. They will work with select vendors delivering superior performance. When next-generation transmission systems are available, cloud SPs will rapidly transition to the latest technology. An open model enables and facilitates this mode of operation; open line systems have become the standard deployment model for cloud SPs, which have constructed their own multi-vendor network management systems.

The CSP community, on the other hand, has also been deploying third-party transmission over existing terrestrial line systems for several years. Having a third-party DWDM transmission over another vendor's line actually predates the industry's current colloquial usage of open line systems. Leading CSPs initially deployed DWDM transmission over legacy systems and achieved an immediate network performance boost. CSPs then went on to deploy third-party DWDM transmission over newer optical lines, achieving even more improvements in performance.

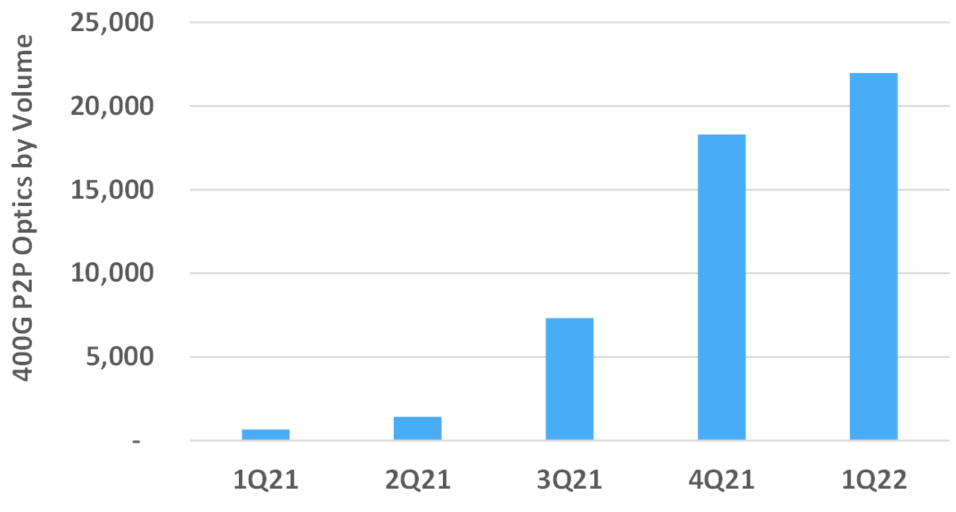
> "Today, Rakuten Mobile does operate with multiple transmission vendors over open optical lines, primarily transmitting 100G and 200G. Rakuten Mobile is currently evaluating 400G solutions."
>
> **Praveen Kumar**
> VP IP Transport
> ***Rakuten Mobile***

The early CSPs efforts met the initial aims but the industry needed to evolve to a standardised operational model. All operational processes, including network discovery and inventory, provisioning, network monitoring-alarm correlation, network protection and restoration, must be supported in a multi-vendor context. A modern operational construct with standardised APIs and data models is foundational to building a more open and agile multi-vendor network.

Change is coming quickly – 400G ZR is ramping

400G ZR is the prototypical open coherent transmission technology, designed to support multi-vendor interoperability at the optical transmission level. 400G ZR was also designed to be deployed in third-party hosts, and will be under multi-vendor software control. The leading cloud providers that initially commissioned 400G ZR for a very specialised application are now beginning to deploy it at scale. The high-volume adoption of 400G ZR signifies that the open optical networks world is legitimate and is now seeing high growth, as shown in **Figure 6**.

Figure 6: 400G ZR shipments, an industry bellwether of momentum in open optical networks



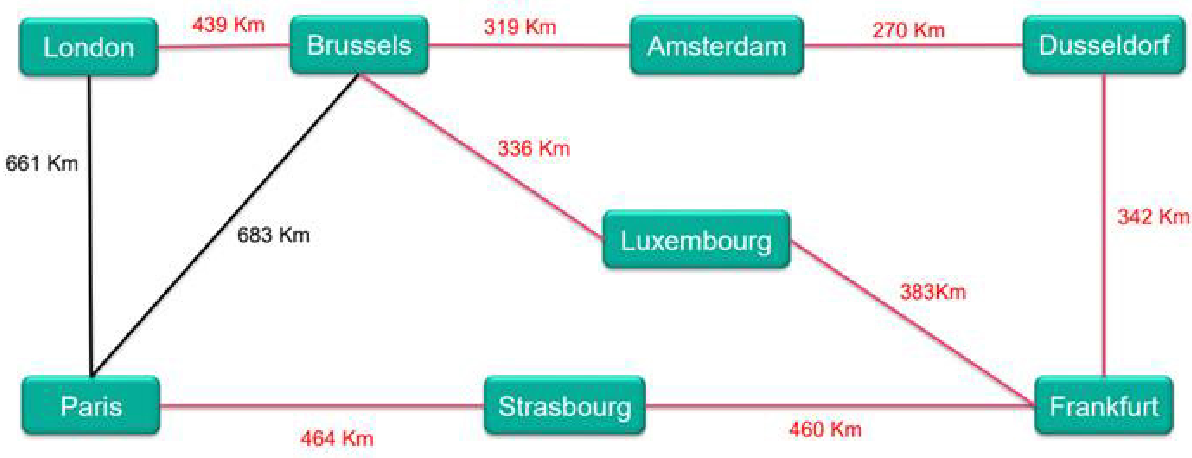
Source: Omdia

While 400G ZR is a very specialised and limited solution, it is a bellwether for the momentum of transition to open optical networks.

At NGON 2022, Colt highlighted its production network 400G ZR+ deployments

UK-headquartered network provider Colt has deployed 400G ZR+ in a router host over an open line system. It used this innovative network configuration for deployments over the Amsterdam, Frankfurt, London, and Paris regions of its pan-European network. The 400G ZR+ deployment was made on links up to 464km. In terms of benefits, Colt cited capex, power, and rack space savings over the previous deployed network configuration, as shown in **Figure 7**.

Figure 7: Colt Packet core transformation using 400G ZR+ (EU Cre)



Red 400G ZR+ (Alien wave long haul OLS)
Black 400G optical wave service (long haul OLS)
Production deployment started early Q4'21

Source: Colt, NGON & DCI World 2022, Barcelona (keynote presentation)

Open environment enablers: Standards and industry fora

The journey to a standardised operational model

For readers that have not been intimately following the standards and industry fora in recent years, initial exposure to the plethora of standards and industry fora initiatives may be daunting. Have no fear—you are not alone. Omdia has spoken with many CSPs that have revealed they lack resources to follow such initiatives in depth, let alone contribute to such industry efforts. Each effort listed subsequently has contributed to and advanced the cause of open environments.

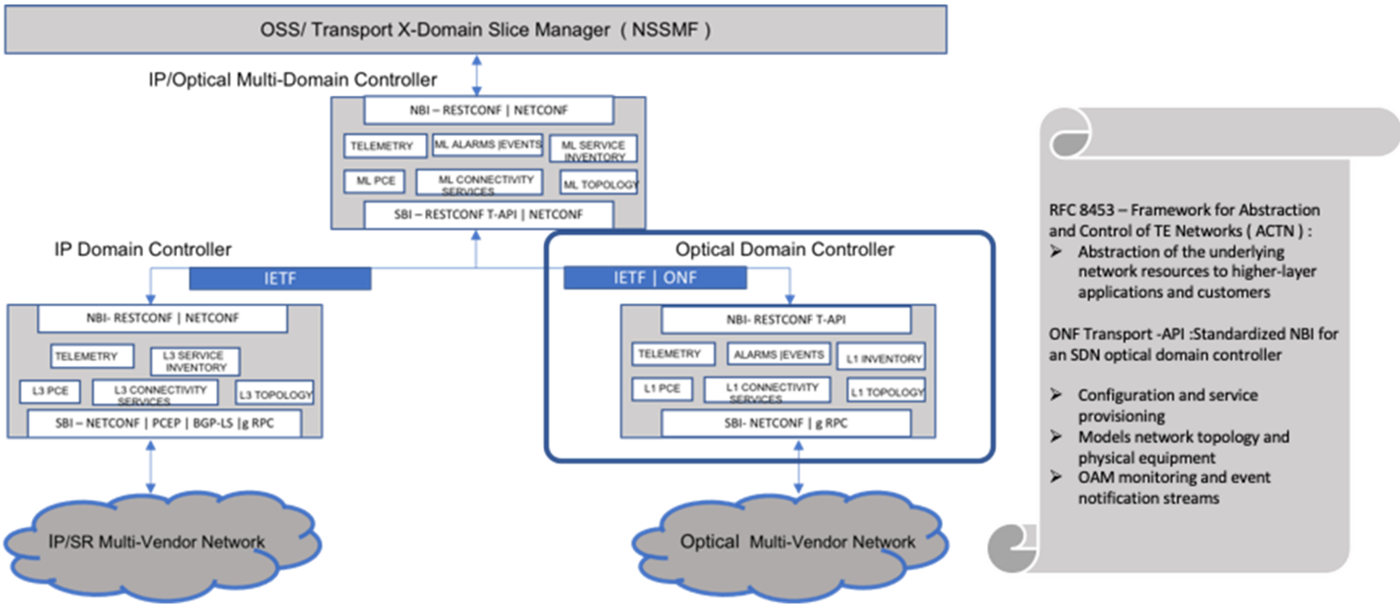
Efforts around standards cover three major transport segments: IP/MPLS, optical networks, and microwave. A very brief outline is provided of these initiatives to date, beginning with a high-level overview of multi-domain Transport SDN, followed by a focused discussion on optical frameworks. The key elements of a standardised operational model are the overall Transport SDN framework with a hierarchical controller construct, interconnecting interfaces between functional elements within the framework (APIs), and data models.

Transport SDN – IETF ACTN SDN framework

The foundational hierarchical framework: IEFT ACTN framework
The IETF ACTN group defined a centralised control regime to enable Transport SDN [IETF RFC 8453]. The group's Transport SDN hierarchical controller framework consists of vendor-specific domain controllers, a multi-vendor optical SDN controller, and a multi-domain controller. Communication between controllers takes place via standardised management protocols. Network attributes are represented by data models.

The major objective of the ACTN's Transport SDN framework is to detach network and service controls from the underlying vendor-specific technology, thereby helping CSPs control multi-vendor environments. The base ACTN architecture defined three controller types and multiple interfaces between the controllers. The initial framework concept, while utilitarian in representation, was iconic, serving as a start for the Transport SDN framework that lives on in the industry today; see IETF ACTN Transport SDN [IETF RFC 8453] in the Appendix.

Figure 8: IETF ACTN's initial Transport SDN framework overview



Source: IETF ACTN Transport SDN [IETF RFC 8453]

Transport SDN enables a separation of the control plane from the data plane. Network resources from multiple vendors and domains can be abstracted to create a single virtualised and holistic network view.

Business and operational challenges from the historic separation of environments

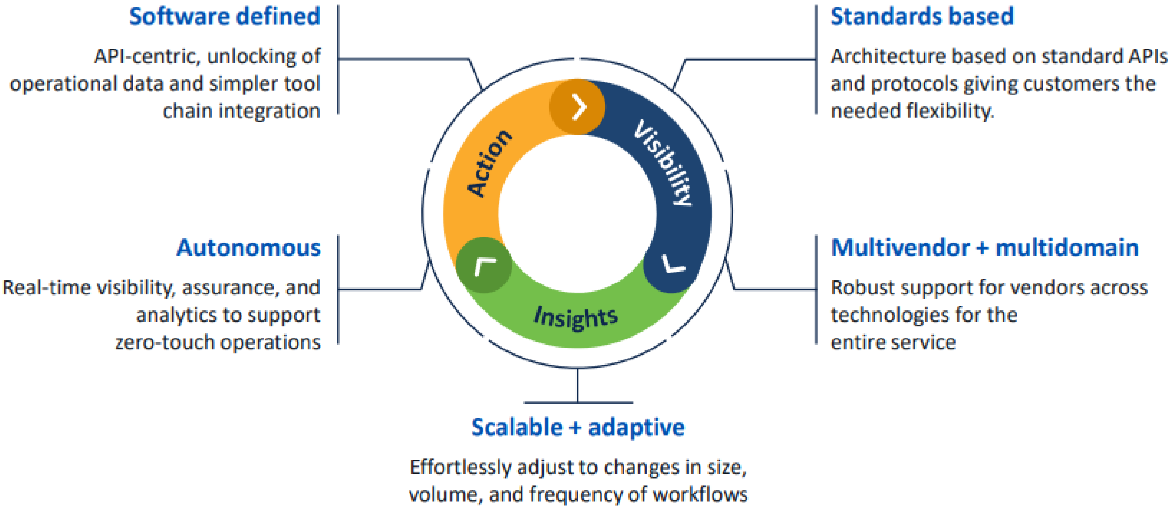
The implications and benefits of implementing a Transport SDN framework are profound; it is nothing short of a generational network management transition. Historically, CSPs had to contend with disparate and separate systems. They also had multiple management systems: one for each optical network vendor, with more systems for other layers such as the IP/MPLS layer. This led to a long list of intrinsic operational inefficiencies, such as the following:

- Multi-pane of glass management
- Lack of unified multi-vendor, multilayer network inventory
- Lack of unified multi-vendor, multilayer topology
- Lack of unified provisioning and service activation
- Lack of network optimization mechanisms
- Lack of integrated performance management
- Lack of integrated fault management
- Manual traffic rerouting for maintenance events
- Lack of standard APIs and data models for integration with upper layer software components

Tenets of multi-vendor, multi-domain environments

CSPs now have the opportunity to evolve to an integrated and unified multi-layer, multi-vendor future.

Figure 9: Tenets of multi-vendor, multi-domain automation



Source: Cisco, PONC 2022

Key Transport SDN functions supported

The key functions to be supported in a Transport SDN environment essentially represent an evolution from the functions required in a classical closed environment to support multi-layer and multi-vendor interoperability. Important network functions to by managed by the Transport SDN framework are as follows:

- Detailed node configuration reporting for inventory purposes
- Network topology exposure for planning/operations purposes
- Service provisioning and activation
- Automatic network optimization mechanisms
- Support for performance management
- Support for fault management
- Traffic rerouting for maintenance events

Business implications of Transport SDN implementation

Transport SDN is a generational step function improving network management and control to enable operational efficiencies, thereby profoundly changing network economics. The central Transport SDN benefits for business are as follows:

> **The entire network equipment procurement process is untethered and unshackled.**

> **With the separation of the control plane and data plane, CSPs are free to introduce new vendors without experiencing network management lock-in.**

> **The freedom to select new vendors enables a more rapid introduction of leading-edge technologies.**

> **CSPs can take advantage of a more continuous performance improvement cycle, optimizing for cost per bit, power, and space.**

Business and operational implications of the open optical line system environment

CSPs now have the opportunity to evolve to a multi-vendor environment supporting open optical networks. One of the most powerful new capabilities of the new open line system environment is the ability to leverage multi-vendor path computation. CSPs will now be able to assess the optical feasibility of third-party optical clients over open line systems via open service, and operations models over standards-based APIs.

The central benefit of an open environment is the enabling of a true multi-vendor construct for the optical network layer. The business implications, as follows, are profound:

> **CSPs are untethered from procurement manipulation by the incumbent optical line vendor CSPs can source DWDM interfaces from a vendor of choice**

> **CSPs are enabled with existing operational lines to take advantage of the latest coherent transmission advances, thereby improving cost per bit, space, and power performance**

ONF/TAPI: The leading API for multi-vendor optical control

From the IETF ACTN framework, the next step focuses on the APIs for optical network control. The ONF developed TAPI in response to the need for multi-vendor optical network control. TAPI v2.1.3 is a production-grade API that has been deployed in real networks, with interoperability tested by the Optical Internetworking Forum (OIF). TAPI is designed to be deployable in a multi-level hierarchy of controllers. On January 31, 2022, the ONF announced the release of an updated Reference Implementation Agreement for TAPI v2.1.3. Within the agreement, over 100 standard alarms and performance monitoring parameters are specified.

The role and position of TAPI within the IETF ACTN framework is as the northbound API (NBI) from the optical network's vendor-specific domain controllers to the hierarchical (multi-domain) controller. The NBI based on ONF's TAPI allows for seamless integration of the vendor-specific or proprietary elements into the open Transport SDN ecosystem.

The OIF recently completed a rigorous interoperability test of the ONF TAPI v2.1.3 API, as defined in the ONF Open Transport Config & Control project. The testing was reported in a press release for the 2020 Transport SDN Application Programming Interface (API) interoperability demonstration, as shown in **Figure 10**. The testing focused on SDN-based programmability, control, and automation using the TAPI NBI between the orchestrator and the optical domain SDN controller, paired with the OpenConfig interface, to open terminal devices in a partial disaggregation model, also shown in **Figure 10**. TAPI supports multiple services, including the following:

Topology service:
Retrieval of network topology, resource availability, and status

Inventory service:
Retrieval of the relationship of logical network objects and their physical location in chassis, slots, and ports, for example

Connectivity service:
Control of creation, modification, and deletion of connectivity services between service endpoints, with specified path constraints

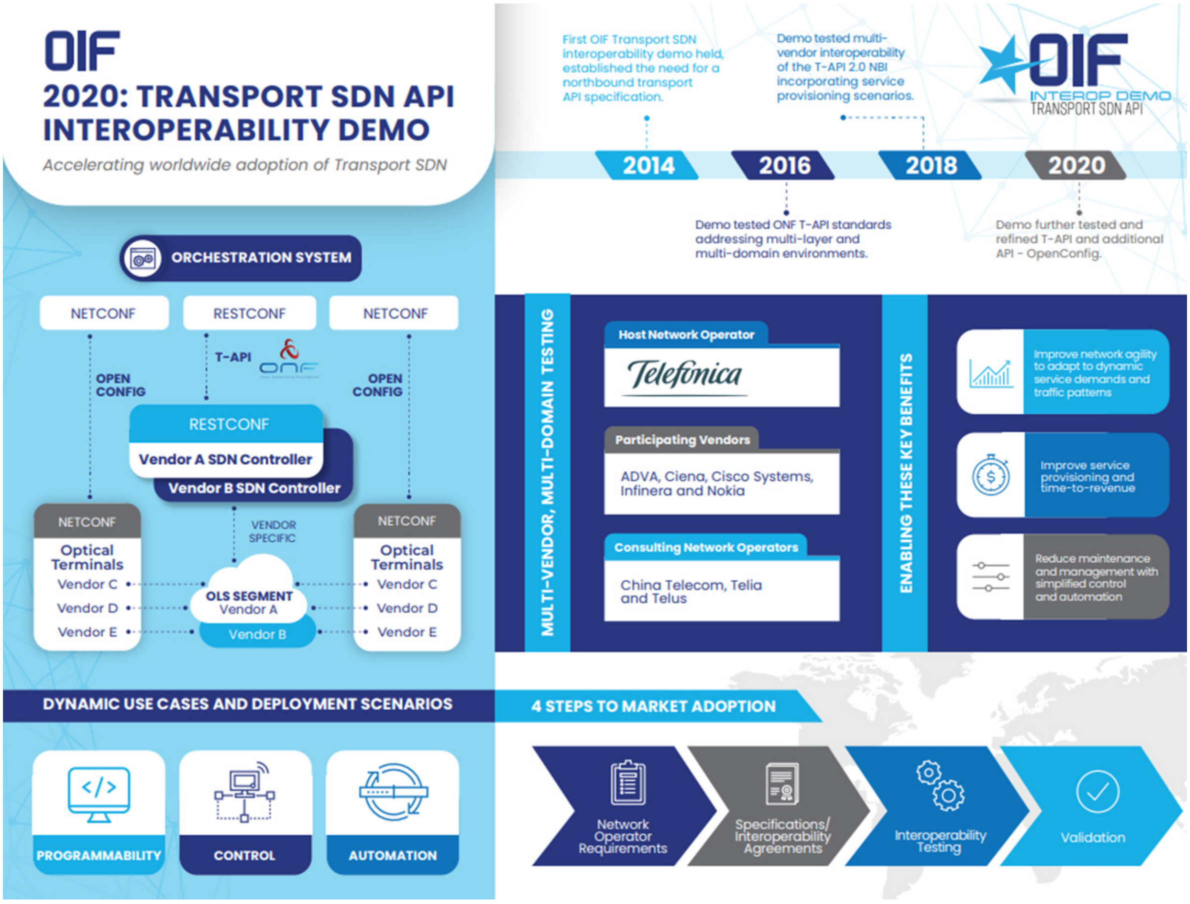
OAM services:
Ability to instantiate OAM monitoring points and control fault and performance monitoring for network troubleshooting

Notification service:
Subscription to autonomous or on-demand information about network events and monitoring data

Higher-level features:
Access to additional services such as network virtualization/slicing and path computation services

For further details, on the OIF's latest interoperability efforts, see further reading in the Appendix.

Figure 10: OIF's interoperability demonstration featuring TAPI and OpenConfig



Source: OIF

OpenConfig: The leading NBI for network terminals

The OpenConfig project has been defined by the member-driven organization, OpenConfig.

OpenConfig is a set of well-defined and consistent common data models for device configuration and streaming telemetry. The data models are written in YANG and model both configuration and operational data in vendor-neutral structures. The OpenConfig project is a collaborative effort between network operators to develop programmatic interfaces and tools for managing networks in a dynamic, vendor-neutral way. The project is driven by operational needs from use cases and requirements across these operators.

The position of OpenConfig in the Transport SDN hierarchy is as the NBI between optical network client terminals to the multi-vendor, multi-domain hierarchical controller. This is contrasted with the proprietary NBI from the optical line system to the hierarchical controller.

OpenConfig defines a large set of YANG models to be supported by a network device. These include models to represent device capabilities and features such as hardware component hierarchy, interfaces, and more. A device may already support many of these features through proprietary, vendor-specific YANG models.

An OpenConfig model provides a common way to configure and manage the same features across vendors. For all vendors that support a feature through OpenConfig, a network operator can use the same YANG model to configure and monitor the feature across different vendor devices.

OpenConfig has adopted a structural convention for YANG models that emphasises the importance of modeling operational state (i.e., monitoring and telemetry data), in addition to configuration data. At a high level, this convention uses specially named config and state containers in every sub-tree to explicitly indicate configuration and operational state data.

OIF's optical multi-vendor interoperability testing

OIF's use case-driven approach to interoperability testing
With the IETF ACTN framework covering hierarchal controllers, the TAPI NBI, the OpenConfig NBI, and a community of participating vendors, the next step is for the industry to conduct multi-vendor interoperability testing with production-ready (or near-production-ready) equipment. The OIF followed a use case-driven approach for multi-vendor optical interoperability testing. The use cases covered are as follows:

- Network discovery
- Connectivity service provisioning
- Physical inventory management
- Resilient services management
- Service maintenance
- Notifications

For many CSPs, particularly those in challenging fiber outage environments, network resilience is critical. All the use cases noted just above have many elements under their top-line uses. For resilient service management, the following subordinate use cases were also tested:

1+1 Diverse service provisioning

1+1 OLP OTS/OMS protection

1+1 OLP line protection with diverse service provisioning

1+1 Diverse service provisioning (eSNCP)

Dynamic restoration for unconstrained and constrained use cases

Dynamic restoration and protection 1+1 for any of the previous cases

Permanent protection 1+1 for any of the previous cases

Reverted protection

Findings and results from OIF Transport SDN testing

The findings and results from OIF testing are as follows:

- **Vendor products demonstrated a high level of maturity and support of operator-favoured use cases, based on TAPI v2.1.3 and OpenConfig APIs. Vendors have rapidly adopted the ONF's TAPI v2.1.3 Reference Implementation Agreement (ONF TR-547) with few deviations.**
- **However, there was a level of inconsistency in interpreting the IETF RESTCONF standard; this was identified as an interoperability issue, especially in standard authentication.**
- **Clarifications to RESTCONF provisioning behavior and implementation scalability were also identified as issues.**
- **A high level of compliance to OpenConfig models was demonstrated by implementations.**
- **However, issues were found in areas such as key exchange algorithms for IETF NETCONF and complex use cases for device provisioning and commissioning.**

Testing showed that the TAPI specification is mature enough to allow participating early-adopter CSPs to continue their aggressive commercial deployment plans, and for all operators to adopt TAPI as a standard NBI in planning open optical transport SDN networks deployments. Continued enhancements to the specification will accelerate the broadscale adoption of TAPI.

The takeaway from OIF testing at the time was that the ecosystem was mature enough for leading CSPs to press on with deployments.

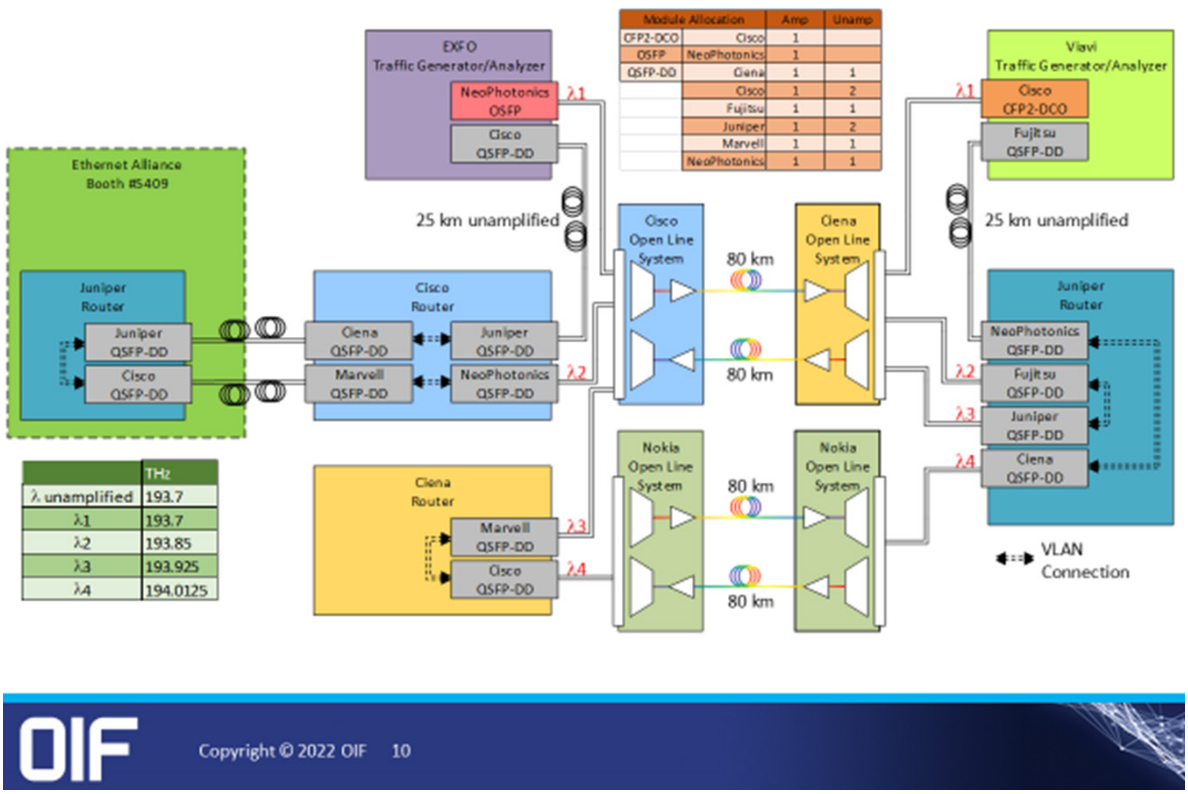
Multi-vendor 400G ZR interoperability demonstration at OFC 2022

Multi-vendor optical interoperability continues to see advancement; a good example of this growing industry consensus and capability was the 400G ZR multi-vendor interoperability demonstration led by the OIF at the Optical Fiber Communication (OFC) 2022 conference. **Figure 11** shows a representation of the demonstration, which included an impressive array of multi-vendor interoperability cases representing many possible industry scenarios.

The demonstration included the following:

- **Multi-vendor open optical lines**
- **Multi-vendor, multi-pluggable types: QSFP-DD, OSFP, and CFP2**
- **Multi-vendor, multiple host support**

Figure 11: OIF's comprehensive 400G ZR interoperability demonstration at OFC 2022



Source: OIF, 400G ZR interoperability demonstration at OFC 2022

Windstream's multi-vendor 400G ZR+ interoperability

On April 18, 2022, Windstream announced the successful completion of its multi-vendor interoperability testing for the 400G ZR+ solution. Participating vendors included II-VI Incorporated and Acacia. The industry standard oFEC algorithms were used in the interoperability trial.

Open network planning

Another capability essential to a truly open and unbiased environment will be the implementation of a vendor-independent network planning construct. GNPy is an open-source software offering building route planning and optimization tools in real-world mesh optical networks. It is based on the Gaussian Noise Model. The GNPy philosophy is to take a spectral and spatial disaggregated approach to the quality of transmission evaluation of lightpaths. With GNPy, hardware is fully abstracted by a topology-weighted graph. Edges represent optical line systems and nodes are ROADMs. Weights represent the quality of transmission metrics including the following:

> **GSNR, filtering penalty, PMD, PDL, CD, latency**

GNPy applications include the following:

- Vendor-agnostic design tool for vendor-operator interactions
- Vendor-agnostic planning tool
- Network virtual stress and load test (e.g., testing the feasibility of L-band deployment)
- QoT-E engine for optimizing line control
- QoT-E in the lightpath computation engine of the network controller to test feasibility

Summarizing the state of multi-vendor optical interoperability

Multi-vendor optical interoperability
The industry is progressing, both in optical interoperability and maturation of the multi-vendor Transport SDN framework. Optical interoperability is progressing well in cases such as 400G ZR, while work is ongoing within the OpenZR+ MSA to support interoperability at longer distances with oFEC. Many CSPs are also deploying book-ended optical transmission solutions over third-party lines. CSPs now have several choices to meet their needs in the open optical domain.

Transport SDN for multi-vendor optical environments
The IETF ACTN Transport SDN framework, the TAPI NBI, and the OpenConfig NBI have been finalised by standards organizations and industry fora. Many CSPs believe that while the standards are largely complete, they require further "tightening" to enable multi-vendor deployments at scale, that are fully integrated and automated. The next steps in the journey are vendor implementation and service provider interoperability testing in multiple environments. Service providers will include new "tightened" requirements in their next RFx processes.

From multi-vendor optical to multi-domain networks

The aforementioned standards groups and industry fora have also been working on the multi-domain transport challenge. Multi-domain control includes IP/MPLS, microwave, and optical layers. Establishing the foundational step of multi-vendor control for optical networks positions CSPs to take the next step and evolve to multi-domain control. As with the preceding discussion, multi-domain transport has both benefits and challenges. Small form-factor optics can be deployed directly in router hosts, leading to a capex savings benefit by eliminating network element interconnect costs. With advances in small form-factor performance, the remaining challenge is the maturation of the operational model. The IETF's transport SDN framework includes IP/MPLS, microwave, and optical layers. For IP/MPLS control, the leading NBIs and southbound interfaces (SBIs) do change to IETF's RESTCONF and NETCONF.

The European CSP was also attracted to the concept of deploying optics directly into router platforms to simplify the network and achieve economic savings. Historically, deploying optics in routers was not practical until optics were miniaturized and required less power.

Maximise performance while integrating and delayering

Windstream articulated a next-generation vision for networks

In discussion with Kim Papakos, principal optical strategist, Windstream
Kim, a renowned industry thought leader on packet-optical evolution, offered his thoughts on a longer-term industry roadmap to a highly-integrated, next-generation packet-optical architecture. Kim's directional statements centered on advances in optical networks and network management systems.

For the next gen optics, Kim articulated Windstream's goals:

- Do want interoperability. Believe that book-ending falls short of the full pluggable promise
- Do want the QSFP-DD form factor
- Do want power handled not just for one pluggable but a fully loaded system
- Want reach capability that handles 70%-80% of their demands up to 400km-600km handling major metros and regional cases

Windstream is not pursuing a series of niche applications. They desire to advance at a meaningful scale. They need a next-generation pluggable to achieve what Windstream has coined "400G ZR++".

On Transport SDN, Windstream is after further simplification. Its current controller configurations align to equipment domains; a packet controller for packet control and an optical controller for optical control, a hierarchal controller ties multiple controllers together.

Windstream is not after a hierarchy or a multitude of domain-specific controllers, but ideally just one packet optical controller. On the software side, Windstream's view is that all the optical performance software available within the DCI platform needs to be ported into the router platform. This implies tighter packet optical integration.

While the industry is currently deploying open optical networks and refining today's operational model for commercial scale, forward-thinking CSPs such as Windstream are looking to shape the future.

For further reading on next-generation networks, see the discussion on routed optical networking.

Conclusions and practical recommendations for CSPs

The latest coherent DWDM transmission deliver rapid benefits

”Do not let perfect be the enemy of the good”
Modern coherent transmission delivers immediate performance benefits, compared with earlier generations of equipment. While the industry is closing in on the “perfect” operational model for scale, many CSPs have already deployed third-party DWDM transmission on their original deployed line systems, which is “good”. These CSPs forged ahead and implemented proprietary (but workable) multi-vendor operational models, either with their own, or their vendor partners’, custom network management developments.

The industry-leading CSPs are capitalizing on the latest coherent advancements to improve network performance at a lower cost. Many vendors have been supporting multi-vendor interoperability for years. The industry’s “body of work and knowledge” has grown significantly and vendors are building their understanding of what it takes to interoperate with other vendors.

Omdia’s recommendation for CSPs today is to invest in open optical network solutions, if they have not already done so. Building hands-on knowledge and understanding is an important goal. CSPs can be begin in a modest manner, keeping an eye on progression. Carrying out POCs is a first step. Potential interoperable vendors can be contained; for example, begin with the two most important vendors. Select problematic, underperforming, basic point-to-point configurations, and develop a plan to deploy the latest advanced coherent optics over legacy lines. With learnings and experiences in hand, open optical network programs can grow and be expanded upon.

Once CSPs have initial open optical network experience under their belts and are more comfortable with the technology, they can look at other network scenarios. Open optical network deployments can be considered on longer and more complex routes with ROADM passthrough. The number of open optical network vendor participants can be expanded from the initial two to potentially three or more.

Finally, third step in the open optical network progression, is to deploy DWDM transmission in alternative hosts such as routers. The industry is evolving along this path. In the past, CSPs have deployed optics in routers, typically in limited quantities to preserve faceplate real estate and router capacity. CSPs are now more aggressively deploying 400G ZR solutions in router hosts for short reach requirements. 400G ZR+ solutions deployed in router host will be the next step in the evolution.

CSPs evaluating a new optical line system

For CSPs evaluating the commissioning of a new optical line system, Omdia has noted the following three topics that merit detailed attention:

Deploy a truly open line; key capabilities include Flexgrid, a wide range of input power, and open APIs

Comprehensive understanding of the multi-vendor interoperability testing track record

Comprehensive understanding of licensing requirements for future third-party transmission

Continue to advocate for advances in standards

Advancing standards requires earnest CSP leadership. The open optical network environment is well beyond the stage of early conceptual days. The deployment record in live networks continues to grow, with open optical networks now poised for a final push to achieve widescale adoption.

The third recommendation is deeper involvement in the standards community and industry fora. To be sure, this requires an investment in time and resources but it will yield an opportunity to be at the forefront of and shape industry discussions. At a minimum, the CSP community should actively track and monitor ongoing standards initiatives. Omdia has highlighted the current set of leading initiatives, while parallel efforts in other fora are ongoing as well. Most efforts around standards are coalescing toward alignment via ongoing efforts to liaise within the industry.

The next step beyond simply monitoring efforts is to make active contributions and participate in key standards initiatives. Many leading CSPs view this as a central effort toward industry advancement and have consistently contributed resources to make this happen.

Closing commentary from Rakuten Mobile

Praveen offered recommendations for others still evaluating open optical network environments:

"The push for open optics is there, it is just a matter of time. The industry is running for it and gunning for it. It's in the labs and the POCs. It is not in the network today in the fullest sense, but it is coming and going to be here, yes."

CSPs must take the plunge into open optics.

The industry will not fully transform in 2022 but in two or three years, integrated IP-optics will see substantial advances.

Invest in operational integration. It is a complex task involving multiple technology languages, but press on.

Appendix

Further reading

Cisco, “Cisco Routed Optical Networking”, retrieved July 2022.

IETF, “Framework for Abstraction and Control of TE Networks (ACTN)”, retrieved July 2022.

OIF, “OIF 2020 Transport SDN API Interoperability Demo”, retrieved July 2022.

OpenConfig, “OpenConfig”, retrieved July 2022.

Windstream, “Windstream Wholesale Successfully Completes Industry’s First 400G ZR+ Interoperability Trials”, retrieved Juy 2022.

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