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Taking IP/Optical Network Visibility and Automation to a New Level

CSPs are ready for more analytics and intelligence

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Contents

Executive Summary

Two epochal drivers of IP/optical network growth are cloud services adoption and 5G radio access network expansion. Cloud services have gained mainstream enterprise acceptance and are driving capacity and capillarity growth. 5G's impact on IP/optical networks is also driving fiber extensions to new densified cell sites and overall access to core capacity expansion. The IP/optical capacity expansion to the edge is crystalizing an additional CSP requirement: a generational upgrade in network management, visibility, and automation. CSPs have an opportunity to progress to both advanced optical and to fully converged cross-domain IP/optical network operations.

The CSP community is more than ready to proceed further with next generation network operations. In the recent Omdia Optical Network Strategies Survey, respondents were asked to rank a set of technologies by their importance to furthering the economic value of optical networks. The top point cited by the CSPs surveyed was: "Embedded instrumentation and being able to process advanced telemetry data." Additionally, 75% of CSPs do expect to achieve converged IP/optical operations by the end of 2023 signifying the importance of evolving to a more unified state of operations.

Omdia, in conversation with Kim Papakos, Principal Optical Strategist at Windstream, heard Windstream's key motivations, strategies, and initiatives for their transition to advanced and converged IP/optical network operations. "Operating and maintaining separate domains of optical and packet network control brings an intrinsic and suboptimal operational overhead. With coherent instrumentation, we can visually see what is going on with the spectrum, enabling many more optical network performance parameters to be tracked," said Kim. Focusing their operational strategy around the client needs has greatly aided Windstream's business model from revenue top-line, capital expenditure, and operational cost-line perspectives.

The next-generation multi-vendor IP/optical network management platform draws upon progress in three foundational areas to move from a manual methods era to a data-driven automated operations era:

- More network performance data is available from the historically opaque optical layer.
- Open APIs provide the common language for multi-layer/vendor communication.
- A growing practical suite of applications leveraging the tighter layer 0-3 interworking has been developed.

The new building blocks and capabilities have provided the foundation for many new IP/optical, auto-assist applications, including:

- Outside fiber plant fault localization

- Real-time visibility of dark networks for restoration events
- Flexible, capex-efficient service restoration
- Enhanced converged IP/optical visibility
- Automated traffic engineering
- Multi-layer service monitoring from a single pane of glass
- Capacity optimization with online network planning

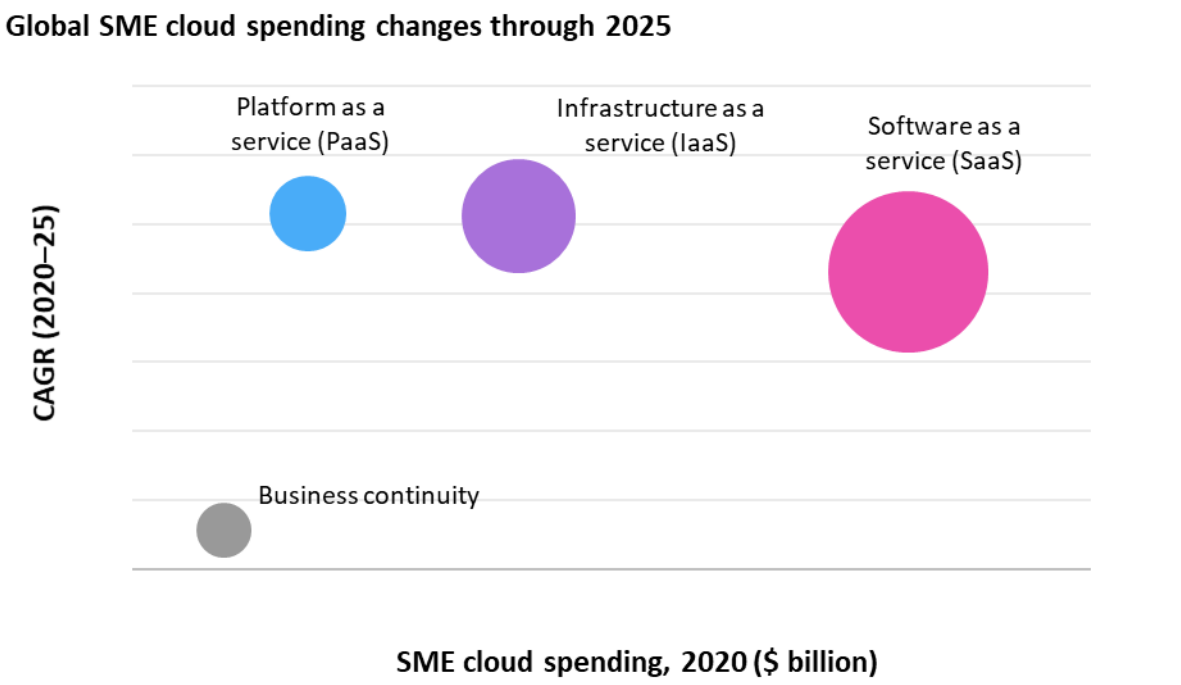
The CSP community has the immediate opportunity to evolve to an “auto-assisted” era with a path towards the long-term goal of fully closed loop and automated network operations.

Heightened performance demands on IP/optical networks

The pace of digitization is accelerating, driven by cloud services and 5G

Two immediate drivers of IP/optical network capacity are cloud services and 5G. Cloud services have gained mainstream enterprise acceptance and have strong potential for additional growth including more cloud service endpoints and additional bandwidth per service. Small and medium-sized enterprises (SMEs) are moving a significant portion of their IT budgets over to a cloud service model. SMEs have rapidly taken to software as a service (SaaS) and Omdia is projecting greater adoption over the next five years. The SaaS market consists of Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), productivity tools, e-commerce, finance, accounting, automated marketing, and other applications contributing to a global $28.3bn market in 2020. Omdia projects the SME SaaS market to grow considerably to 2025. Mission critical IT services must be underpinned by a bandwidth service adhering to a higher SLA standard. Communications Service Providers (CSPs) require enhanced visibility of service and network performance to be able to now adhere to more stringent latency requirements.

Figure 1: Global SME cloud spending changes through 2025

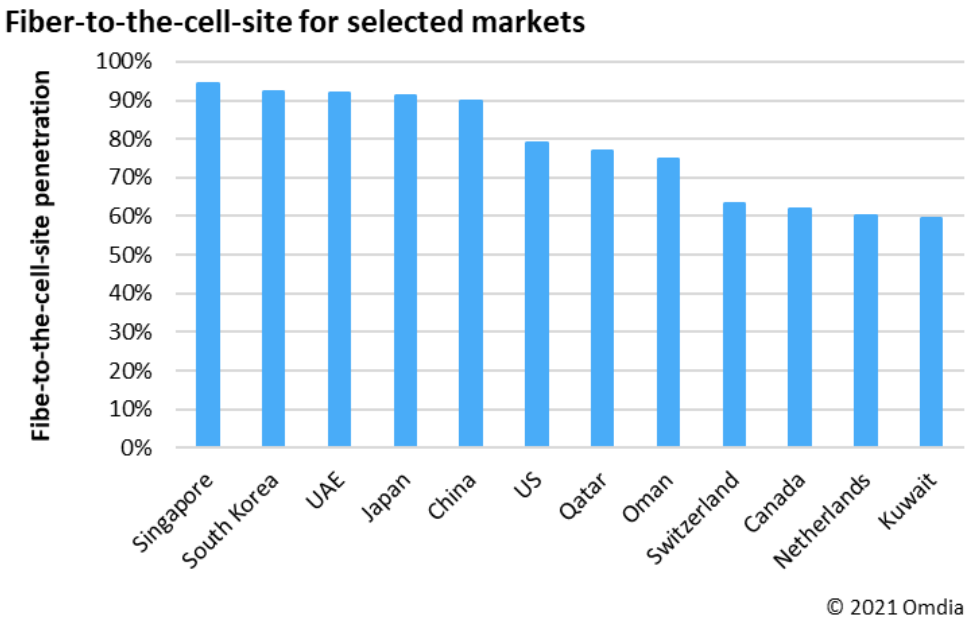


Source: Omdia SME Spending on Cloud Services

5G rollouts are also a very significant optical network driver

Much of the industry 5G news revolves around new applications, spectrum, and new radio capabilities. 5G will also drive a vast expansion of IP/optical networks. The cell tower radio units will be optical connectivity endpoints via very high-speed gray optics or xWDM solutions for the front haul portion of the network. The optical tributaries will drive higher and higher capacities into the arterial portions of the network. Traffic in the midhaul and backhaul portions of the network will scale to multiples of 100G and 400G wavelengths. 5G is a key enabler for national competitiveness and many country markets are accelerating “fiber-to-the-cell-site” initiatives.

Figure 2: Fiber cell site penetration for selected markets



Source: Omdia Fiber Development Index 2020

Cloud and 5G services will run over a converged IP/optical infrastructure. Optical networks are rapidly scaling, approaching 10 million optical coherent ports in operation. Optical networks are evolving in terms of reach to meet the cloud and 5G endpoint densification needs and to support modern architectures with distributed edge compute.

CSP Challenge: Operating efficiently in a rapidly scaling environment

The cloud service growth, the 5G RAN growth and the IP/optical capacity expansion to the edge are driving a further CSP need: a generational upgrade in network management, visibility, and automation. If IP and optical network technology layers must operate in close concert, then once independent network management solutions must also operate in a more tightly coordinated manner. Tighter multi-layer integration also entails greater multi-vendor interoperability in the network management domain, as CSPs typically work with at least two vendors in every layer in the network. The management of the network needs to be faster. CSPs' desire and direction of travel is to move from a manual human-operated era, through an auto-assist era to and ultimately onto the fully automated era.

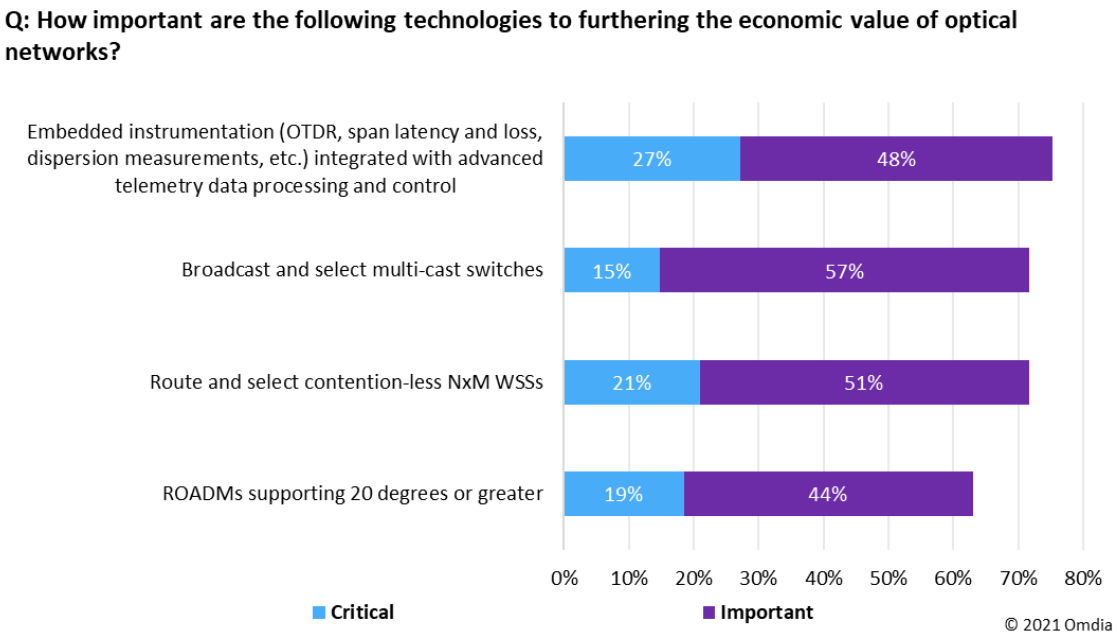
CSPs also need to evolve from the historical reactive stance on fault management to a more proactive footing on predicting faults prior to service affecting events. CSPs look to leverage the latest predictive capabilities enabled by detailed network telemetry and data analytics algorithms.

The automation imperative from a CSP perspective

Furthering the economic value of optical networks

In the recent Omdia Optical Network Strategies Survey, respondents were asked to rank a set of technologies by their importance to furthering the economic value of optical networks. The top point cited by the CSPs surveyed was: “Embedded instrumentation and being able to process advanced telemetry data.”

Figure 3: Technologies for furthering economic value of optical networks

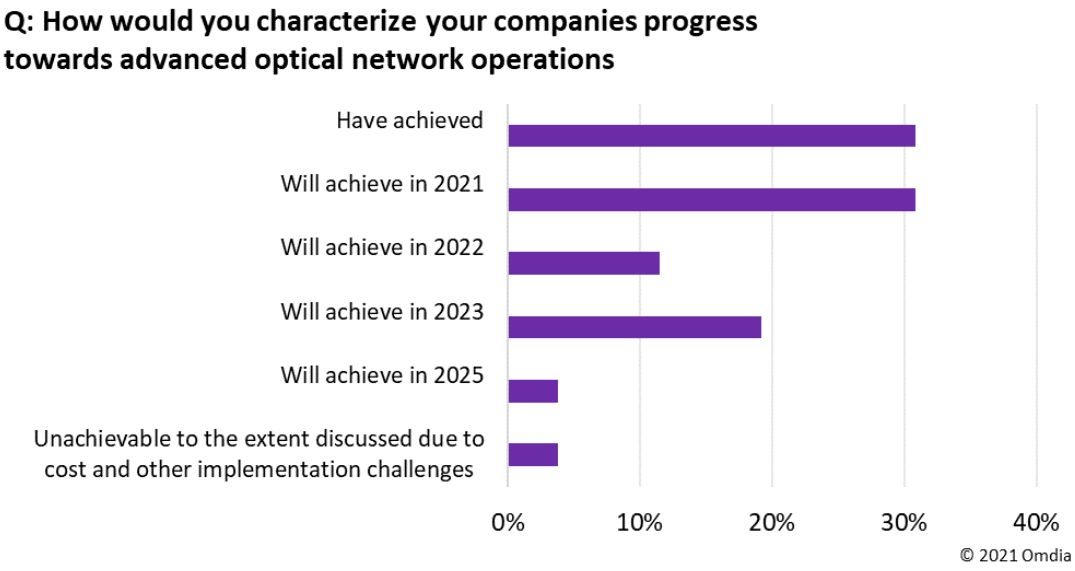


Source: Omdia Optical Network Strategies Survey - 2021

CSP progress to advanced optical network operations

Omdia conducted a second survey, Omdia's Optical Network Vendor Leadership Survey, probing into CSPs' progress towards advanced optical networks and converged cross-domain IP/optical network operations. The survey covered both topics in depth. Two representative questions and CSP responses are highlighted below. Omdia characterized advanced optical network operations as visibility to every optical endpoint such as fiber-to-the-cell-tower and fiber-to-the-enterprise, including measured latency performance and key optical performance parameters. 60% of CSP survey respondents cited achieving advanced optical networks now or by the end of 2021. CSPs are rapidly embracing new optical network visibility capabilities and applications.

Figure 4: How would you characterize your companies progress towards advanced optical network operations?



Source: Omdia Optical Network Vendor Leadership Survey 2021

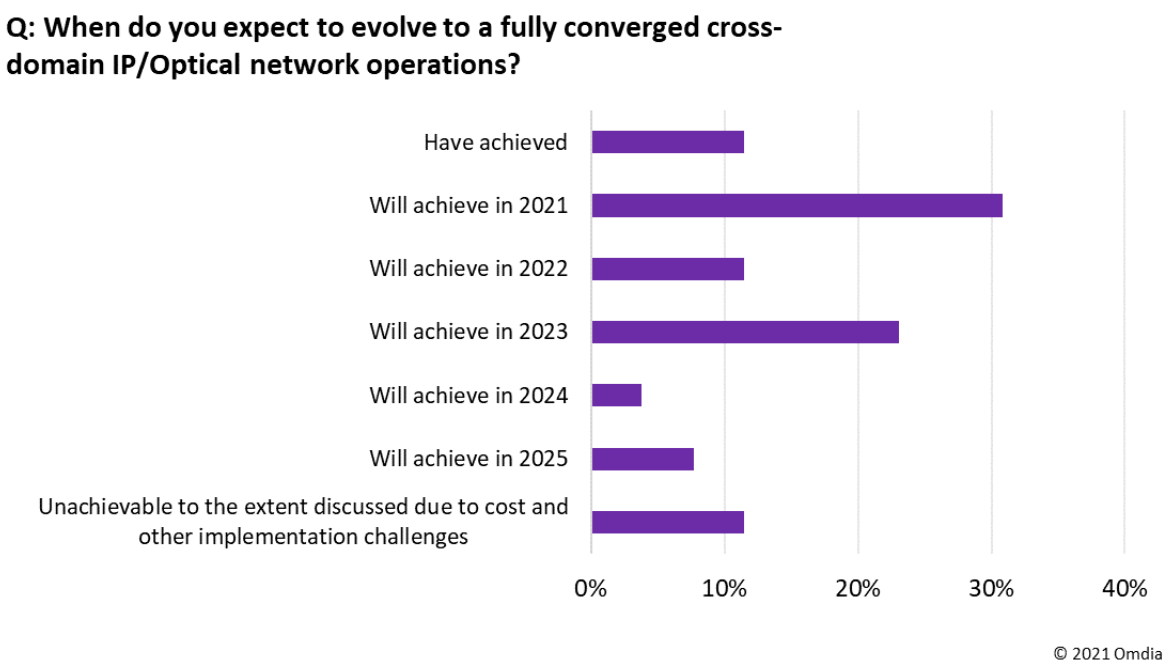
CSP progress to fully converged cross-domain IP/optical network operations?

CSPs were asked about the progress to fully converged cross-domain IP/optical network operations. Omdia characterized fully converged IP/optical operations as evolved from "siloed" and would include items such as:

- Accurate and updated cross-domain network inventory and multi-layer topology discovery.
- Converged IP/optical visibility of optical diversity.
- Coordinated IP/optical operations control.
- Cost effective multi-layer protection.
- Intent-based and cross-domain connection management including interworking with multi-layer domain controllers.

Just over 10% of CSP survey respondents claimed they were currently achieving fully converged. cross-domain IP/optical network operations. While achieving advanced optical network operations falls within one classic network management domain, converged IP/optical involves two formerly disparate domains. Advanced optics also benefits from new, cost effective instrumentation, available as an auxiliary benefit for coherent transmission technology. Converged IP/optical requires further integration and development efforts. Some 75% of CSPs do expect to achieve converged IP/optical operations by the end of 2023 signifying the importance of evolving to a more unified state of operations.

Figure 5: When will you evolve to a fully converged cross-domain IP/Optic operations?



Source: Omdia Optical Network Vendor Leadership Survey - 2021

IP/optical innovator Windstream continues to move the industry forward

In conversation with Kim Papakos, Principal Optical Strategist, Windstream

The back story: Network and operational challenges, leading to new objectives

Windstream has a long history of advancing, innovating, and extending the boundaries on next generation network control by collaborating with their vendors and sub-system technology partners. Windstream's vision for its operations began with a view from their clients' perspective. Windstream's enterprise and network operator clients are technology savvy, discerning wholesale buyers. Windstream's clients desire innovative solutions to meet their high-bandwidth needs with advanced network visibility, frictionless turn-up for rapid scalability, and maximum diversity for premium service availability.

Figure 6: The Windstream Wholesale national network

Source: Windstream

Prior to the recent network management upgrade, Windstream had several network and operational pain points. Kim Papakos, Principal Optical Strategist at Windstream, opened our discussion, "Operating and maintaining separate domains of optical and packet network control brings an intrinsic and suboptimal operational overhead. Removing domain-translating network equipment between the optical and packet domains leads to an equipment savings."

Windstream desired a network with advanced, distributed, cost-effective optical instrumentation for both their optical savvy clients and for Windstream directly. Windstream had additional goals: lower latency, enhanced network robustness via more comprehensive diversity, convergence of IP and optical architectures, and "fine-grained" network visibility. Historically, network performance reporting intervals could be aggregated in 15-minute timeslots which could mask transient, short-term but performance-affecting events. Client businesses, especially network operators, could be in a position where their own customers could see the impact of a short-term performance affecting event, but the business itself did not have immediate and direct visibility of the network issue.

Windstream also desired a new service offering innovation: terrestrial spectrum services. Over in the submarine market, spectrum services had filled a market mid-point, enabling wholesale clients to purchase spectrum cost-efficiently and equip based on current bandwidth needs. As bandwidth needs grow, clients can re-equip the transmission equipment based on the latest transmission technology and operate within the original spectrum. Clients do not need to overpay up front but have a means to rapidly scale economically when needed. Windstream desired to port this service concept into the terrestrial environment.

In summary, for their next generation operations environment, Windstream had several key objectives:

- Introduce new spectrum services to meet emerging client needs.
- Elevate the client experience to the next level with enhanced visibility.
- Leverage coherent optics instrumentation to the fullest.
- Gain deep analytical insights across the entire network to build towards predictive capabilities.
- Enable automation through APIs for hierarchical orchestration of services.

The adopted solution

In October 2020, Windstream selected Ciena for the Next-Gen Fiber-to-the-Tower Modernization Effort, deploying Ciena's Manage, Control, and Plan (MCP) domain controller. Windstream cited growing mobile network operator (MNO) needs for 10G to the towers with 100G aggregated bandwidth handoffs at client switching offices, and a requirement for comprehensive network management. Following on, in June 2021, Windstream announced deployment of a substantial coherent optics transmission network for its Intelligent Converged Optical Network (ICON). Coherent optics are widely known for their high-bandwidth transmission capabilities, and they also deliver optical network instrumentation benefits. The enhanced network performance datasets are fed upwards to MCP for enhanced management, control, and planning.

"Coherent has done a lot for instrumentation, leading to great strides in spectrum analysis. Today's coherent solutions in a small form factor, at an economical cost point, provide a rich set of optical telemetry data with accurate and fine resolution. The greater visibility really simplifies network operations and planning," noted Kim.

Windstream also leveraged MCP's support of submarine spectrum services and ported capabilities over into the terrestrial service environment. Spectrum services provide a key new layer 0 offering, fulfilling a client need for flexibility beyond defined high-capacity, lit fiber-optic services.

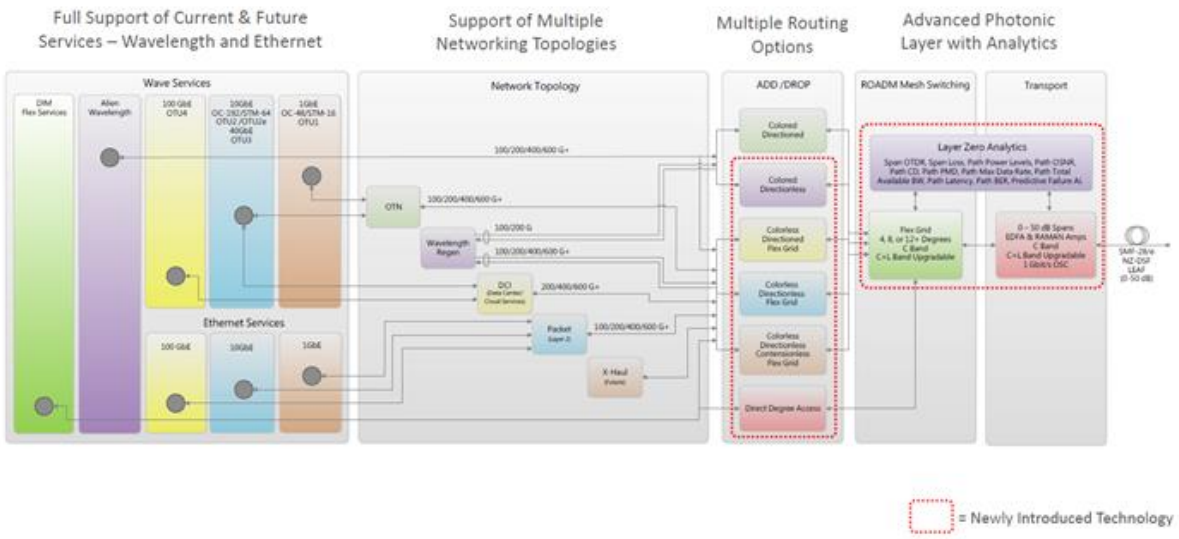
Benefits achieved: Advanced network operations for greater reliability

With coherent instrumentation and a next-generation domain controller, a richer set of optical network performance parameters are available, all the way out to the edge of the network. The new data can be transmitted northbound, to the operations application suite designed to process the dataset, present it informatively and recommend optimal courses of action to assure wavelength and Ethernet services running over the optical infrastructure. With greater visibility of latency variations, optical paths can be optimized for reduction of overall latency.

"With coherent instrumentation, we can visually see what is going on with the spectrum with many more optical network performance parameters tracked such as: path loss and gain, SOP (state of polarization), PDL (polarization dependent loss), SNR (signal to noise ratio) and more," Kim said.

Aerial fibers can be vulnerable to loss in high wind conditions. Any bend in the fiber, can lead to loss. Tracking PDL, continuously, over time, can provide weather related operational insight to CSPs. Lightning strikes can impact aerial fiber performance by rotating the signals state of polarization. Tracking a fiber's SOP, identifies weather related service affecting events. Kim noted that, "embedded instrumentation also eliminates the cost of external optical measurement devices." Refer to Figure 7 to see how Windstream's newly introduced advanced photonic layer with analytics supports multiple networking technologies and services.

Figure 7: Windstream advanced photonic layer with analytics



Source: Windstream

Additionally, Windstream is evolving to a predictive operational model to get out in front of future potential service affecting events. "We are utilizing self-learning algorithms, to analyze historical data to identify patterns and trends to build our predictive capability for potential future service affecting events," added Kim. The strategy is to stitch data together over multiple layers to gain greatest insight.

Our discussion was focused on a major step forward in operational capabilities, but coherent instrumentation has aided the Windstream sales side. "The advanced instrumentation capability provides Windstream's clients with solid and visible assurance of network performance from both a Day 1 and ongoing perspective. Removing uncertainty and doubt of network and service performance, provides our clients the assurance that they will receive the service that they expect. In turn, overall visibility and control removes barriers within the Windstream sales cycle, by aiding, and speeding up service provisioning. In addition, coherent instrumentation is the independent judge for isolation of service performance issues across complex networks," concluded Kim.

Organizational operational integration benefits

Converged IP and optical domain control are a key operational goal for many CSPs. Achieving the goal, often requires the mastery of both technology and organization integration. Kim proffered, “The new instrumentation with new network data sets is leading to a common language of communication between the optical and packet operational teams. The common language is breaking down former barriers to communication leading to an environment of enhanced collaboration and interworking.” With a multi-layer domain controller in hand, Windstream sees increased efficiency in day-to-day operations.

Summary: Net gains

Focusing their operational strategy around the client needs, has greatly aided Windstream’s business model from revenue top-line, capital expenditure, and operational cost-line perspectives.

New IP/Optical Foundations & Applications

Foundations for integrated IP/optical visibility & automation

The new building blocks and capabilities

The next-generation multi-vendor IP/optical network management platform draws upon progress in three foundational areas to move from manual methods to data-driven automated operations:

- More network performance data is available from the historically opaque optical layer.
- Open APIs provide the common language for multi-layer/vendor communication.
- A growing practical suite of applications leveraging the tighter layer 0-3 interworking.

More optical telemetry data available for real-time state information

More telemetry data is available from the optical layer than ever before via the proliferation of embedded coherent instrumentation. Real-time optical performance can be monitored, more key metrics tracked: effective signal to noise ratio, chromatic dispersion, pre-FEC bit error rates and latency. The enhanced optical visibility can be extended from the optical core to the optical edge.

"Open APIs" are central to network visibility and operations automation

Open APIs such as Netconf, GPRC, OpenConfig, and Restful API, can now be utilized to share performance data in a non-proprietary manner. Via Open APIs, network monitoring, service monitoring, and traffic engineering data can be sent northbound from each layer 0-3 device in the CSP's network, irrespective of the vendor. CSPs will now have a more comprehensive view of the current state of the network across layers and vendors. Open APIs, such as TAPI, WebSocket and Restful API, are equally important for integration of domain controllers with backend operational support systems. This allows for end-to-end automation of operational workflows.

Practical applications delivering immediate benefits

With a more complete network view, CSPs can take advantage of a growing suite of advanced data analytics capabilities and applications across layers. For example, with real-time visibility of optical

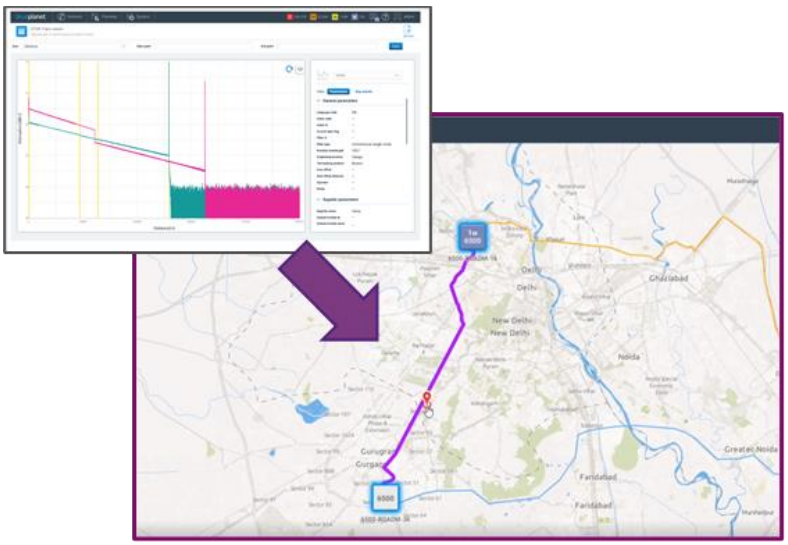
line system SNR margin, CSPs can convert margin into optical capacity on demand as needed. Visibility of multi-vendor IP/MPLS networks and analysis of routing behavior can be correlated with performance metrics to better assure IP services. And network utilization metrics across layer 0-3 can highlight capacity exhaustion or underused resources, to improve future capacity planning.

Outside fiber plant fault localization

CSP challenge: Fiber cuts are a network reality. Improper splices and excessive attenuation conditions can also impact service and network performance. When fiber cuts or performance affecting events occur, CSPs need to localize the fault and dispatch teams to address the faults. Historically, standalone Optical Time-Domain Reflectometers (OTDRs) would need to be positioned at either ends of the troubled link, to help localize the fault.

Today's solution: Embedded OTDRs are built into the photonic lines throughout the network. Physical transport and positioning of testing equipment is no longer required. Faults can be rapidly located "on-screen" and repair technicians can be dispatched to the precise fault location. OTDR traces can also be used proactively to ensure network health and in a validation mode after every network installation and maintenance event.

Figure 8: Proactive fiber monitoring and faster troubleshooting with PinPoint



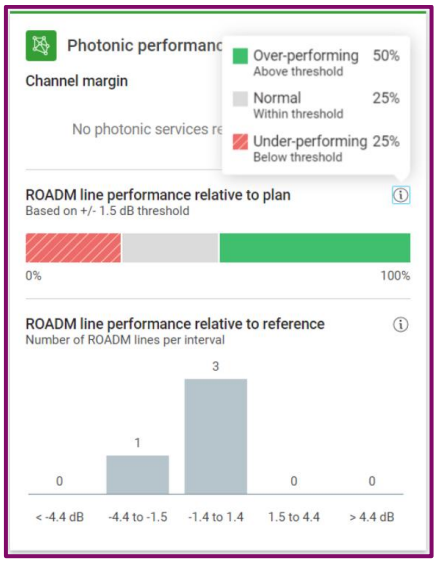
Source: Ciena

Real-time visibility of dark networks for restoration events

CSP challenge: There can be a network scenario where an optical line has been deployed without the transmission capacity. The line has value for potential restoration events but, without active monitoring, the up-to-the-minute state of the line is an unknown. CSPs would have a view of the original designed capacity but not necessarily have the current actual capacity, particularly if the link has been untended for some time.

Today's solution: New real-time performance metrics within the line system and end-to-end photonic layer automation are used to provide instant visibility into the state of the photonic network, especially insightful for "dark" sections of the network. The state of the dark links can be fed to domain controllers to support path calculations. The dark network visibility application may also identify preventative maintenance needs. CSPs can monitor the health of dark optical restoration paths, detect silent failures, and proactively fix problems, in preparation for smooth and faultless link activation.

Figure 9: Real-time visibility into line system performance with Photonic Performance Gauge



Source: Ciena

Flexible, capex-efficient service restoration

CSP challenge: Optical core outages will inevitably impact supported layer 0-3 services. A primary high-capacity wavelength may be deployed near its reach limitation. In an outage scenario, the restoration path, may exceed the reach capability of the initial primary wavelength. CSPs could be in the position of choosing between several suboptimal options. The restoration path may have been pre-equipped with standby capacity and service may be restored in this manner. This option is capex-intensive in that, due to crossing the reach limit, regeneration resources would have to be committed.

Today's solution: With programmable modulation formats, CSPs can operate a wavelength at its maximum capacity for a given link reach. If the protect path is significantly longer, the modulation format can be adjusted to derate capacity for the protect path reach. For example, if the primary path can support an 800G wavelength, the protect path may still be able to carry a 200G to 600G wavelength without requiring intermediate regeneration. The more dynamic capability provides the CSP community with a more capex-efficient option and a much faster option if idle regeneration

capacity has not been deployed. Incremental optical layer survivability increases the reliability of the supported layer 2-3 customer services.

Enhanced converged IP/optical visibility

CSP challenge: Managing a multi-layer, multi-vendor network has been an ongoing arduous task. CSPs have integrated network visibility challenges. Historically, CSPs have had visibility into individual networks layers and individual vendors in their network but often did not have an integrated "single pane of glass" view of the entire multi-layer, multi-vendor network. The integration was accomplished manually by network operators drawing upon multiple, disparate tools.

Today's solution: CSPs can now leverage open APIs such as Netconf, GPRC, OpenConfig, and Restful API. With open APIs, network and service monitoring and traffic engineering data can be sent northbound. Visualization tools integrate the multiple network layer state information and enable unified network state presentation, helping accelerate provisioning and troubleshooting activities.

Automated traffic engineering

CSP challenge: Coordination between optical and IP network operations for traffic engineering is a complex process. Each team manages each technology layer to minimize outage scenarios, potentially over-engineering and under-utilizing the network infrastructure. Even with a "single pane of glass" view, it is time-consuming to extract the most pertinent data to optimize traffic flows for performance and reliability, while utilizing infrastructure most efficiently.

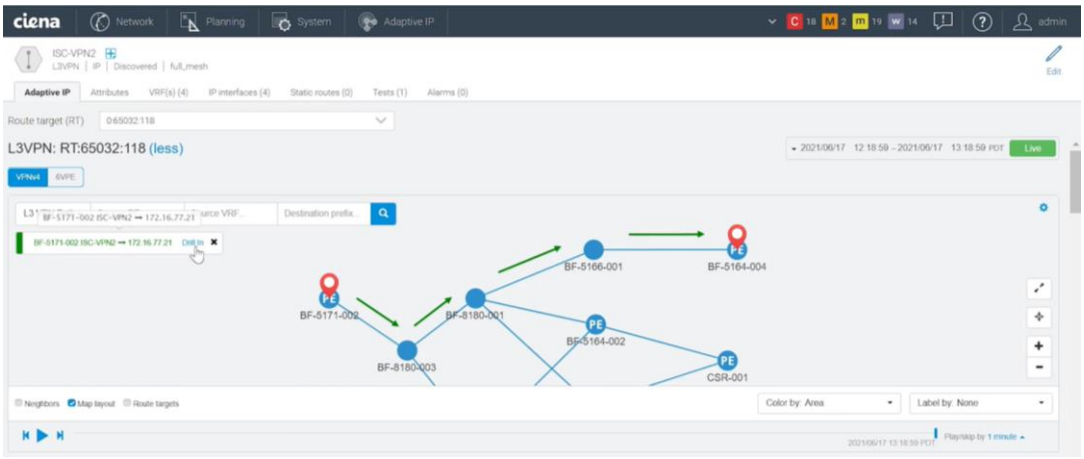
Today's solution: CSPs can adopt streamlined IP protocols such as Segment Routing (SR) with the ability to provision SR-Traffic Engineering (TE) tunnels based on specified policies, constraints, and network state. Such constraints could include Shared Risk Link Groups (SRLG) values associated with underlying optical network elements to assure route diversity. Automated path computation engines can present route alternatives, simplifying and speeding up traffic engineering activities.

Multi-layer service monitoring from a single-pane-of-glass

CSP challenge: Client service monitoring across multiple service management domains has been a historic CSP challenge. Service views from disparate platforms have placed the correlation burden on the shoulders of the operational staff, requiring time and expertise to sort out complex network conditions. Network performance visualization has been a disjoint multi-screen exercise.

Today's solution: Network monitoring of routing and optical behaviors is possible from a single pane-of-glass. The IP network control plane can be monitored real-time, forensically and in a "what if?" planning mode. IP paths and MPLS, RSVP-TE, and segment routing tunnels can be correlated with the underlying optical layer. Real-time monitoring of client services can be combined with path-aware performance analytics and correlated with routing behavior performance metrics. This helps in diagnosing performance issues and resolving troubles. Routing behaviors tracked can include interface utilization, errors, drops, link delay and jitter, router CPU, and memory utilization. The combined and correlated service, IP and optical status can be presented in a unified view highlighting the client service status and all the underpinning network layers of IP, Ethernet, and optical.

Figure 10: Real-time IP path visibility with Adaptive IP™ Apps



Source: Ciena with permission

Capacity optimization with online network planning

CSP challenge: Network planning must begin with an accurate, up-to-the-minute view of network inventory. In the historic mode of operation, CSPs have relied upon off-line planning tools and spreadsheets from prior network planning efforts. The Achilles' heel in this approach is drift between actual network inventory data and the network inventory view in the offline planning tools. Actual fiber loss values may also differ significantly from planned fiber loss—if there is less loss than expected, CSPs may be losing out on monetizing their optical assets. The net results of conflicting data views can be costly and time-consuming to correct. Today's solution: Planning begins with accurate on-line, real time network inventory state and actual fiber loss measurements. Network plans can be created for greenfield network cases and for capacity additions to existing operational networks. Multiple network growth scenarios can be analyzed, and the optimal, robust plan can be commissioned by deploying additional equipment as required and then implemented via software turn-up. With the real-time network view, an additional capability can be brought to bear: network utilization across layer 0-3. Network utilization identifies situations where the optical transport network is filling and moving towards running hot and/or where average and peak throughput of packet services is reaching high levels. With thresholds, CSPs can be alerted to future capacity-add needs, in advance of any customer impact.

The direction of travel: From manual to auto assist to fully closed loop

CSPs are motivated to embrace a more automated environment with detailed network visibility. The ultimate long-term network management goal is a fully autonomous network: self-sensing, self-adjusting, and self-optimizing, with a fully closed loop capability. CSPs can begin the journey today and immediately take advantage of many new auto-assist capabilities and positively move the needle on revenue acceleration and operational performance.

Appendix

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