# Unlocking the Value of Open Packet Optical Transport

Transport networks that liberate service providers from vendor lock-in and complex operations

### Challenge

Service providers want to accelerate network innovation and lower transport cost-per-bit as new services based on cloud, 5G, IoT, and multigigabit broadband technologies create new revenue opportunities.

### Solution

With Programmable Photonic Layer and proNX Optical Director, Juniper opens up and disaggregates the packet optical transport network, enabling multilayer visibility and coordination while aligning the operational environment with SDN and DevOps models.

### Benefits

- **Low-cost infrastructure and operations:** Eliminates vendor lock-in, freeing operators to deploy the right technologies for their network and budget
- **Multilayer visibility and coordination:** Provides full-stack visibility, reduces overprovisioning costs, and optimizes network capacity
- **Disaggregated network control:** Executes control plane changes with service continuity, allowing fine-tuning of open line system performance

In today's networks, optical capacity is typically activated and controlled in an isolated layer on closed, vertically integrated systems that bind the network operator to a particular vendor's technology, roadmap, and operational environment. Such optical vendor lock-in is the norm, resulting in high system costs and complex, single-layer operations that impede the operator's ability to innovate and take advantage of new revenue opportunities.

Due to the rapid growth of a diverse range of advanced services, transport networks must be optimized for steadily growing, unpredictable traffic flows, whether between data centers or from increasingly mobile end users to high-capacity content and applications. Network operators want to move faster, creating and delivering services on demand with each network layer optimized for scale, resiliency, and cost-per-bit of transport capacity.

## The Challenge

Whether a service provider is developing new cloud services, investing in 5G and the Internet of Things (IoT), or expanding fiber capacity to meet the next wave of traffic growth, vendor lock-in keeps network element costs high, bounds the operator to vendor-specific roadmaps, and limits the user's ability to scale in lock-step with traffic growth. Vendor-specific management and control functions for each layer are still the norm, resulting in stranded capacity and protracted service provisioning cycles.

Meanwhile, traffic volumes continue to grow rapidly, in particular in the metro where trends such as video content caching, multi-gigabit broadband service adoption, and the expansion of distributed cloud architectures are keeping traffic within metro network boundaries. In addition to raw traffic growth, service providers also face increasingly variable traffic patterns as the number and type of network end points expands, and as latency-sensitive applications and high-capacity content represent a larger percentage of traffic volume.

These changes are driving service providers to reimagine their metro network architecture and operations. To meet demand for new engines of business growth, operators are evolving their networks from closed to open designs; collapsing single-layer silos to gain visibility and coordination across layers; and migrating from highly complex operations to simpler, more automated network management and control.

## The Juniper Networks Programmable Photonic Layer Solution

Service providers know that if they can free themselves from vendor lock-in, closed systems, and complex, single-layer operations, they can significantly reduce TCO and move faster to drive revenue growth from new service opportunities. With Programmable Photonic Layer, Juniper brings its pedigree of openness, programmability, and automation to the packet-optical transport domain, helping operators create an agile, software-driven, low-cost transport network ready for business growth.

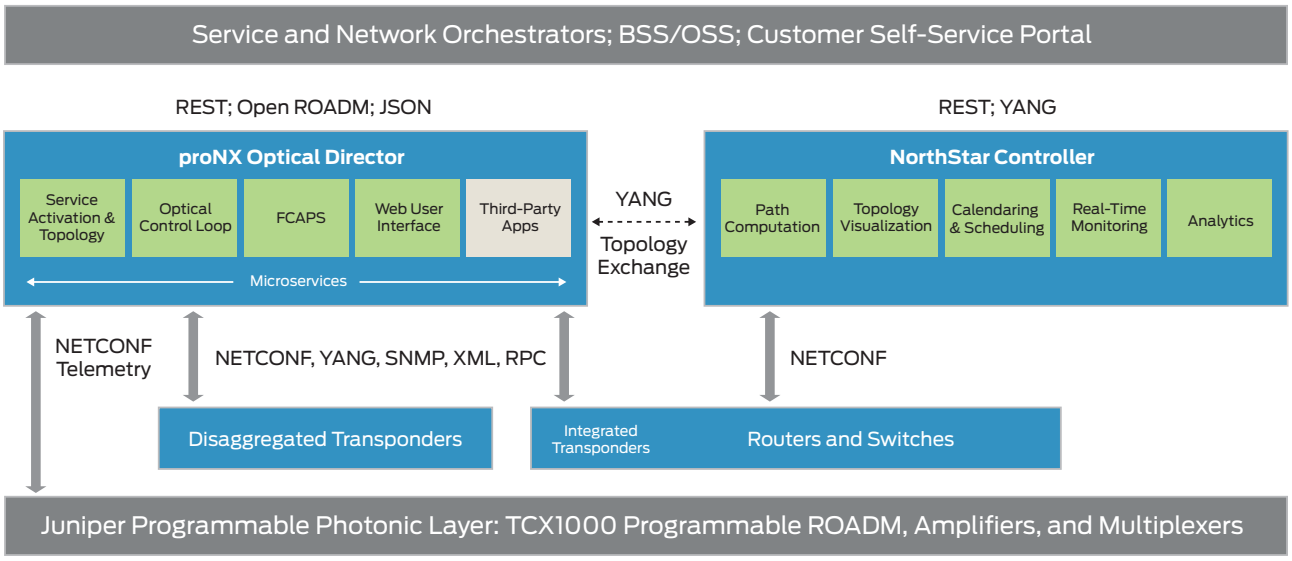


Figure 1: Juniper packet optical solution architecture

Programmable Photonic Layer is an open line system solution consisting of Juniper Networks® TCX Series Optical Transport System ROADM, amplifier, and multiplexing elements. All of these components are managed and controlled via open, standards-based application programming interfaces (APIs) by Juniper Networks proNX Optical Director, a microservices-based optical network management and control platform. As an open line system, Programmable Photonic Layer enables service providers to deploy Juniper and third-party transponders that are independent of the line system, creating a low-cost, flexible environment for scaling network capacity.

## Programmable Photonic Layer Features and Benefits

Table 1: Features and Benefits

| Features | Benefits |
|---|---|
| Disaggregated control plane, centralized and managed as a microservice | • Simplifies control plane software updates and upgrades while maintaining service continuity<br>• Fine-tunes and optimizes open line system performance<br>• Lowers line system hardware costs<br>• Supports full visibility and manageability of control plane attributes per channel |
| Microservices-based software architecture (proNX Optical Director) | • Eases transition to a DevOps model<br>• Promotes reliability by dispersing functionality across multiple services<br>• Includes high-velocity software deployment and new features added at scale<br>• Provides more flexible scaling of software functions<br>• Supports easy onboarding of customer-developed and third-party applications<br>• Offers fast software installation and turn-up, driven by Ansible automation tools |
| End-to-end multilayer architecture | • Allows operators to choose an end-to-end Juniper packet optical architecture or use the solution's openness to adopt a best-of-breed approach |
| Open and programmable hardware | • Eliminates vendor lock-in; operators choose the transponder technology (Juniper or alien wavelengths) that best fits their application and budget<br>• Helps operators migrate faster to open transport architectures |
| Multidimensional scalability | • Addresses any high-capacity use case, as operators can scale in terms of number of universal ports (up to 20) and a total line capacity of 25.6 Tbps |
| Flexible and grid-ready | • Protects investments by enabling seamless upgrades from 100 Gbps to 200 Gbps, 400 Gbps, and beyond |
| Versatile use of multiplexing and amplification | • Increases the number of hardware configurations and use cases supported by the line system |
| Open APIs | • Makes it easier to program system ports and configure the underlying line system<br>• Allows use of telemetry for network monitoring and data collection |
| Automated end-to-end service activation | • Lowers operating costs by eliminating manual provisioning processes<br>• Carries over the service activation capabilities of Juniper Networks proNX Service Manager |

# Solution Components

## proNX Optical Director

With deep software development resources and expertise throughout the network stack, Juniper Programmable Photonic Layer pushes the boundaries of openness, programmability, and automation in packet optical transport.

proNX Optical Director is a software platform designed to manage and control Juniper Programmable Photonic Layer open line system elements and Juniper's coherent dense wavelength-division multiplexing (DWDM) transponder-based solutions. These include the Juniper Networks BTI Series Packet Optical Platforms and TCX Series Optical Transport Systems, as well as integrated DWDM transponders on MX Series 3D Universal Edge Routers, PTX Series Packet Transport Routers, and QFX Series switches. Based on a highly available, extensible microservices-based architecture, proNX Optical Director supports easy and reliable deployment, scale, and integration of applications and services—whether from Juniper, an operator software development team, or a third-party developer.

With Juniper Programmable Photonic Layer, Juniper disaggregates photonic control from the underlying line system hardware, simplifying control modifications, reducing line system costs, and ensuring service continuity. In addition, disaggregation yields the following optical performance benefits:

- Automatic configuration of Programmable Photonic Layer to compensate for optical path losses, including the ability to track changes in optical losses to accommodate variations in the installed fiber plant
- Per-channel power management through the optical path, including optimization of optical signal-to-noise ratio (OSNR) and nonlinearities through the transmission path of the channel

By disaggregating the photonic control function, Juniper provides much greater flexibility and the opportunity to customize these controls, addressing specific customer needs more quickly and reliably. Compared to traditional line system elements, where control is decentralized at the node level, control plane disaggregation allows for much wider network visibility, enabling more granular performance optimization and superior management of the optical path.

For instance, if there is a challenging segment in the middle of a long link, the operator can use proNX Optical Director to tailor control parameters for that segment independent of the rest of the link, optimizing system reach and performance. In a network with embedded control software on the photonic layer nodes, this level of fine-tuning is operationally complex and leads to service interruption.

Programmability is a hallmark of proNX Optical Director, which includes a Web user interface with Network Configuration Protocol (NETCONF) and telemetry APIs southbound for easy network element configurability and service monitoring. Rich, standards-based REST APIs northbound help the network operator simply and cost-effectively integrate proNX Optical Director into the orchestration and business support systems/operations support systems (BSS/OSS) layers.

The microservices-based proNX Optical Director also integrates seamlessly with Juniper Networks NorthStar Controller over standards-based APIs, enabling multilayer visibility and coordination. Using a standards-based YANG model, proNX Optical Director exchanges optical network topology with NorthStar to execute multilayer link protection schemes and gain visibility from the photonic layer to Layer 3.

## TCX Series Optical Transport Systems

An integral part of Programmable Photonic Layer, the TCX Series Optical Transport System portfolio provides the foundation for a comprehensive, open, and programmable packet optical transport network. For the Programmable Photonic Layer, the TCX Series consists of the TCX1000 Programmable ROADM, amplifier, and multiplexer elements that round out the open line system solution.

The TCX1000 Programmable ROADM works alongside TCX1000 amplifiers and multiplexers to deliver the essential elements of an open line system. It is a colorless, directionless, grid-ready reconfigurable optical add/drop multiplexer (ROADM) that scales up to 25.6 Tbps per line, supporting 20 universal node-side ports that can serve in various combinations, including channel access (single or multiplex) and degree switching. The TCX1000 can transmit over distances up to 3800 km without repeaters, making it a flexible solution for metro, long-haul, and subsea applications.

The TCX1000 Programmable ROADM supports numerous multiplexing methods. For example, users can start with a few direct-connect channels and, as traffic levels increase, add an external multiplexer such as a TCX1000 2-degree 8-channel mux-demux to a free port, allowing them to start with a modest configuration and grow the ROADM node capacity gradually while maintaining existing services.

The TCX1000 provides two solutions for colorless and flexible grid multiplexing in the form of a transponder-direct connection to the ROADM or an 8-way passive multiplexer. The direct connect provides a simple way to offer up to 20 colorless connections; the transponder is directly connected to a TCX1000 Programmable ROADM port and the channel is provisioned without requiring an additional external multiplexer.

The Programmable Photonic Layer solution also includes the TCX1000 Inline Amplifier (ILA), which provides a low-cost, low-noise, high-density amplification solution for sites that do not require access to traffic on the line. The TCX1000 ILA provides gain-flattened amplification, with the ability to tilt the spectrum for coarse spectrum equalization. The ILA embeds an OSC solution that provides a 100 Mbps Ethernet channel on a 1511 nm carrier; this is compatible with the TCX1000 Programmable ROADM optical supervisory channel, which allows ILA nodes to be accessed remotely using in-band management.

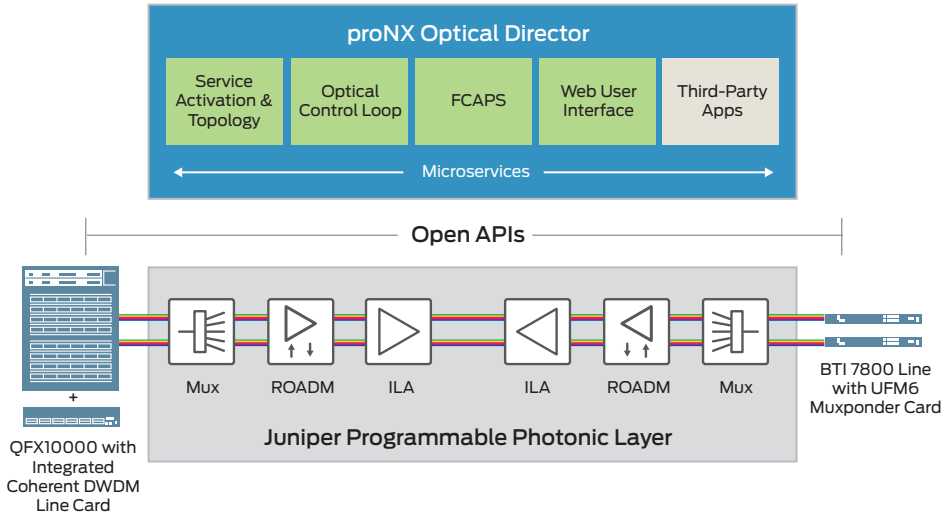


Figure 2: Juniper Programmable Photonic Layer used in Open Cloud Interconnect DCI solution with QFX10000 and BTI7800

## Synergy with Juniper Solutions

As a massively scalable foundation for packet optical transport networks, Programmable Photonic Layer is a natural extension of, and an ideal complement to, a wide variety of Juniper solutions, including the following.

### Open Cloud Interconnect

Programmable Photonic Layer adds another layer of versatility to Open Cloud Interconnect, Juniper's Data Center Interconnect (DCI) solution, by providing support for point-to-point and full-mesh topologies with up to 20 degrees, enabling a smooth migration to high-capacity (200+ Gbps) bit rates and hyperscale links.

With proNX Optical Director, service providers have a single management and control point for Programmable Photonic Layer, as well as all Juniper transponder solutions, including deployments from the data center edge and spine. Critical to DCI, proNX Optical Director also provides real-time visibility into and manageability of optical power level per channel.

### Converged Supercore

As an open and programmable line system, Programmable Photonic Layer simplifies the use of integrated transponders on PTX Series and other Juniper routers in Converged Supercore® networks. The TCX1000 Programmable ROADM provides a high-capacity, flex-grid ready ROADM for core upgrades to 200 Gbps and beyond. Support for 20 universal ports enables operators to more easily build partial and full mesh cores. In addition, service providers can exchange optical network topology information from proNX Optical Director with NorthStar Controller for multilayer core visibility and coordination, which complements NorthStar's core label-switched path (LSP) optimization capabilities.

### Juniper Networks Professional Services

As with any technology that is in transition, packet optical poses certain challenges and risks—challenges in deploying the technology in a seamless and timely manner, and risks associated with infrastructure and operational readiness. Juniper Professional Services' Service Link offering brings years of optical engineering experience to your project, providing complete engineering, furnish, and installation (EF&I) services and bridging the gaps in your organization's capabilities. Service Link professionals can perform fiber characterization to assure your physical plant is ready for these new higher bandwidths, while Juniper Professional Services representatives address any system alarms and perform network health checks to ensure all nodes are up to date and suitable for 200+ Gbps rates. Remote assistance and live traffic cutover support services are also available.

## Summary—Juniper Unlocks the Value of Open, Programmable Packet Optical Transport

With Programmable Photonic Layer, Juniper is redefining open, programmable, and disaggregated architecture for packet optical transport, applying software-based innovation to help network operators lower TCO and accelerate network innovation to dominate the market for new, high-growth services. A combination of TCX Series programmable hardware and proNX Optical Director network management and control software protects operator investments in the transport layer—the foundation for business growth, network performance, and operational agility.

## Next Steps

For more information about Juniper Programmable Photonic Layer and other Juniper packet-optical solutions, please visit us at http://www.juniper.net/us/en/solutions/packet-optical.

## About Juniper Networks

Juniper Networks challenges the status quo with products, solutions and services that transform the economics of networking. Our team co-innovates with customers and partners to deliver automated, scalable and secure networks with agility, performance and value. Additional information can be found at Juniper Networks or connect with Juniper on Twitter and Facebook.

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