

Apollo Open Optical Networking

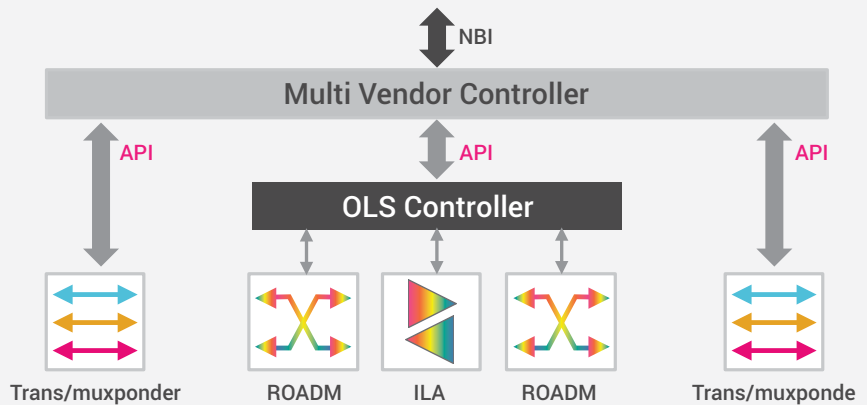
Fully and Partially Disaggregated Solutions



Communications service providers are pursuing two approaches to building disaggregated optical networks based on integrating network elements or subsystems with open and standard interfaces.

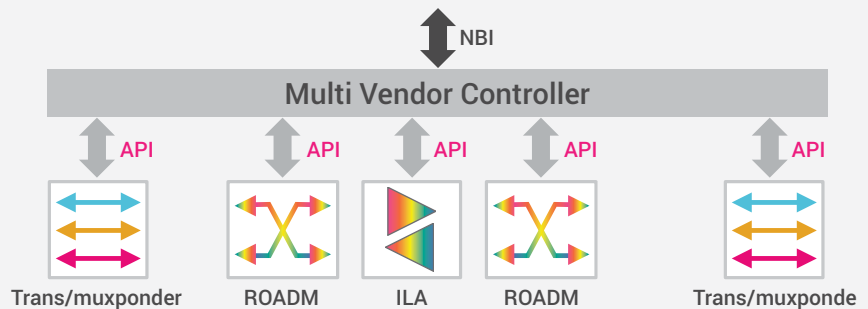
Partially Disaggregated

The Optical Line System (OLS) and Transponders & Muxponders are the disaggregated elements controlled via open and standard interfaces.



Fully Disaggregated

Each network element is controlled via its own open and standard interface, with integration performed by a multi-vendor controller.



Disaggregation is projected to deliver multiple benefits:



Best in class innovation for each network element or sub-system,



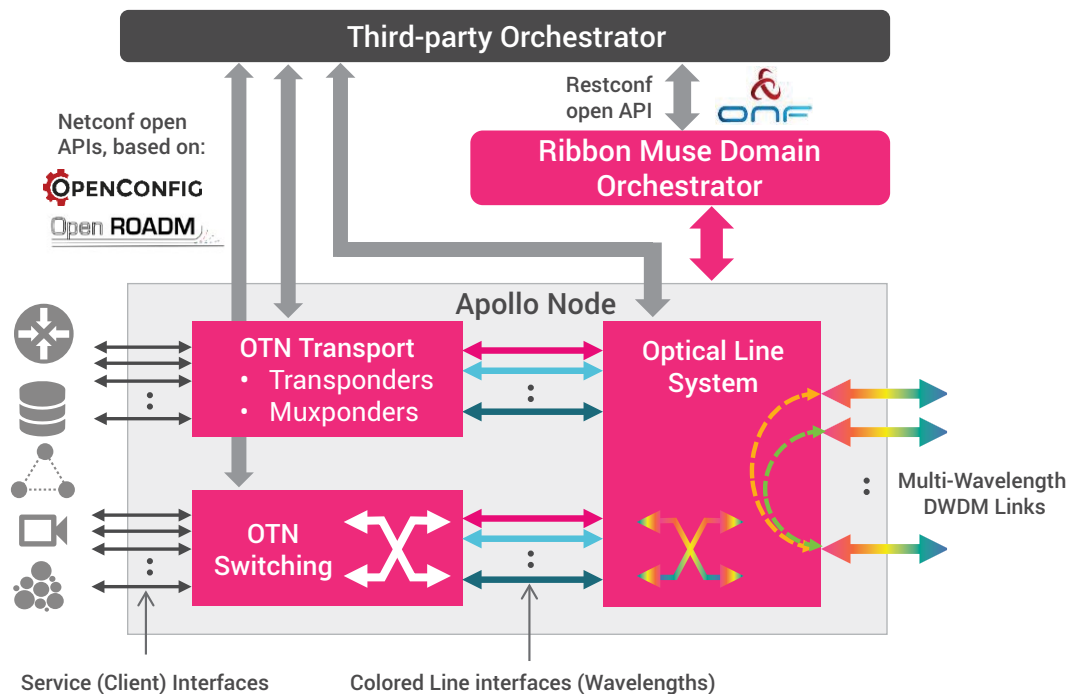
Freedom from vendor lock-in enabling solution flexibility and price competition,



Staggered network evolution, for example, a faster cycle for transmission subsystems with a longer life for optical line systems.

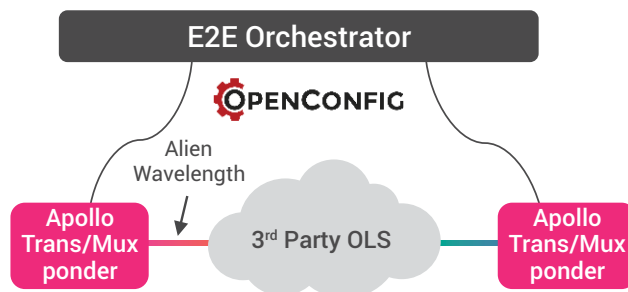
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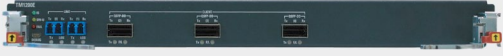



Ribbon's Apollo optical networking system supports both approaches. Apollo enables partially disaggregated solutions by consolidating control of any mix of its OTN Transport, OTN Switching, and OLS elements via Ribbon's Muse Domain Orchestrator, which functions here as an optical domain controller that is controllable via a Restconf interface using open standard APIs. Apollo also enables fully disaggregated solutions by supporting Netconf interfaces with open standard APIs on each network element (NE) directly.



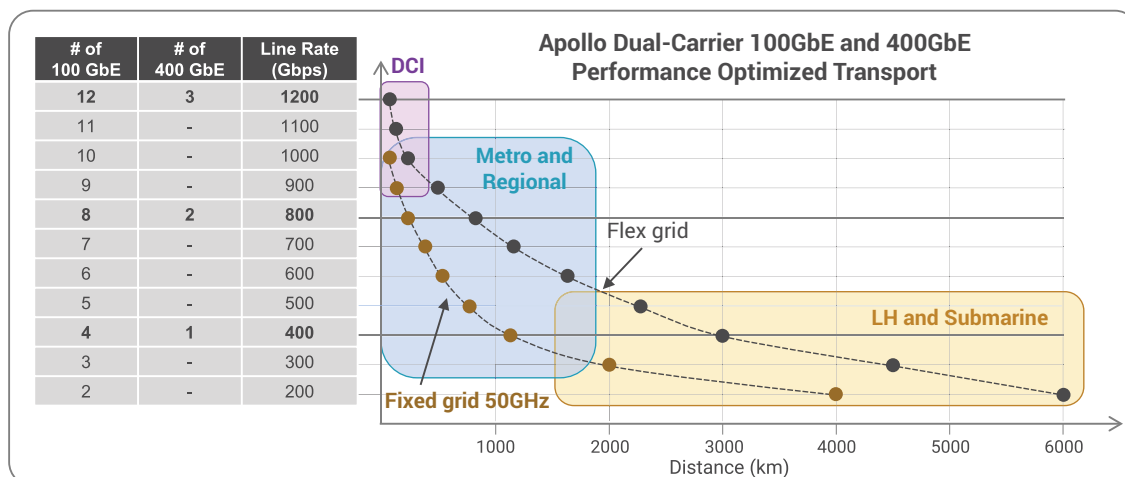
Disaggregated OTN Transport (Open Terminals)

Apollo transponder and muxponder blades can run as alien wavelengths over other vendors' optical line systems (OLS). This enables taking advantage of the many performance and economic benefits of Apollo transport while retaining an existing OLS. The table summarizes Apollo's main transport blades, covering all application spaces. These blades are deployable in all Apollo transport platforms (except the 9901X which is a 1RU standalone platform.)



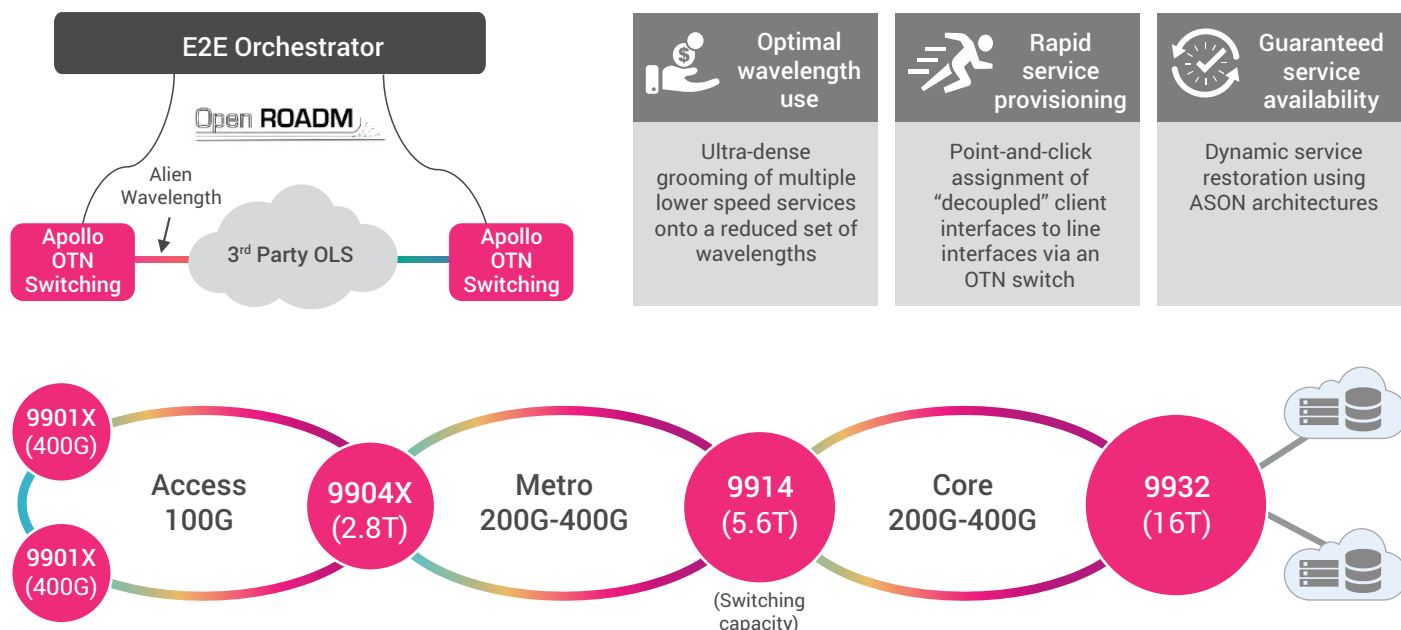
	Card	Application	Coherent Line Rate (Max)
TM1200/TM800		High performance 100GbE transport	1200G
TM1200E/TM800E		High performance 400GbE transport	1200G
TM400_2		Power-cost optimized 100GbE & 400GbE transport	400G
TM200EN		Multiservice transport with optical encryption	200G
9901X Platform		10GbE and low speed multiservice transport	100G

Of particular note are the high performance 100GbE and 400GbE transport blades, where each blade has two line interfaces that can operate either independently or in a dual-carrier mode. In dual-carrier mode (see diagram) the two line interfaces effectively combine into a single channel to achieve rates of 200G to 1200G in 100G increments, delivering extraordinary capacity and distance capabilities. These blades can operate in both greenfield flex grid networks and brownfield fixed grid 50/100GHz networks.

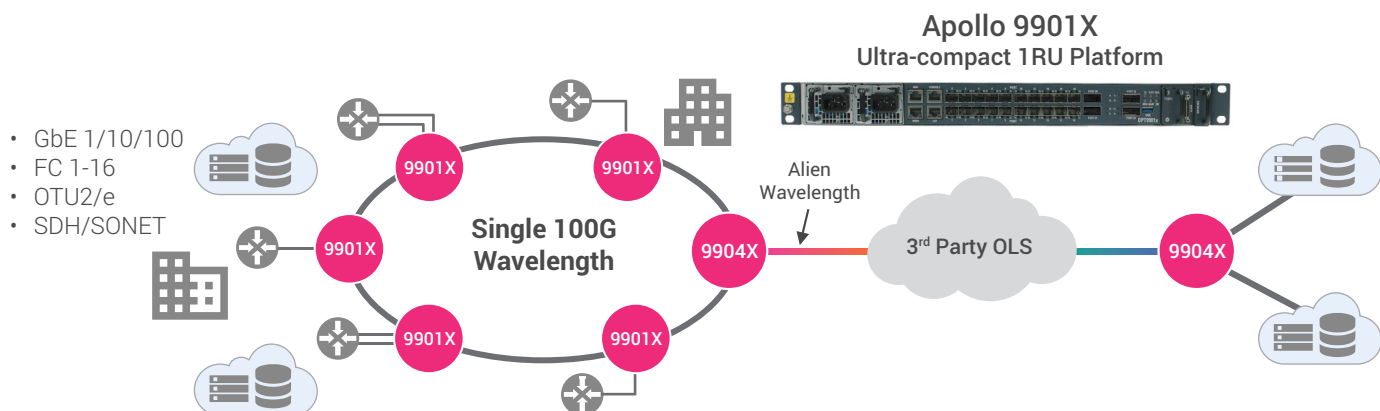


Disaggregated OTN Switching

OTN switching can add multiple benefits as an overlay to an existing DWDM network, including wavelength grooming, rapid service provisioning, and dynamic restoration. Apollo makes it easy to obtain these benefits as an overlay solution with its complete family of access to core OTN switches all controllable independently.



One of the most exciting applications for a disaggregated overlay application is rapid provisioning of layer 1 business services using Apollo's access and metro OTN switches. L1 business services connect Enterprises to the Internet and to data centers at 1G or greater speeds, and are very lucrative for SPs. However, it has always been a challenge to provision these services quickly and economically due to the fixed and rigid nature of access networks. Apollo solves this problem with its ultra-economical 9901X access OTN switch. In the configuration example below, these switches are deployed around a 100G gray or colored wavelength access ring. Upon receiving service requests, it becomes a simple matter to connect the clients to the 9901X via pluggable interfaces and then rapidly turn up end-to-end transport under software control. This is all deployable over an existing optical network.



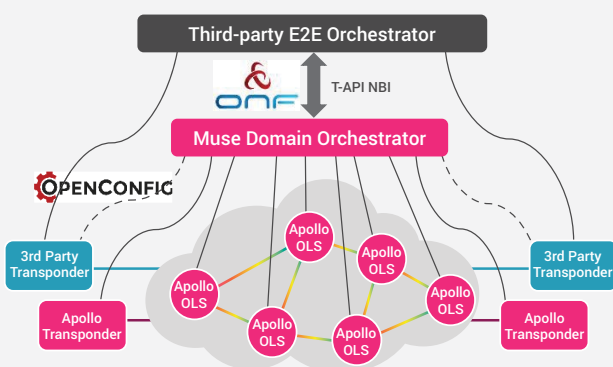
Disaggregated Optical Line System

Apollo's open OLS is exceptionally modular with a powerful array of value-added capabilities, including alien wavelengths, alien spectrum, spectrum slicing, dynamic wavelength restoration, integrated performance monitoring, and fiber health management. It is tailorable to fulfill the requirements of any OLS disaggregation strategy.

Apollo's OLS optimizes optical performance across the network based on an extensive selection of ROADM and amplifier modules. These are configurable for low to high degree nodes for mesh, star, and ring topologies, using either economical broadcast-and-select or low loss route-and-select architectures, and C/CD/CDC (colorless, directionless, contentionless) add-drop combinations. Moreover, Apollo OLS nodes feature integrated Optical Channel Monitoring (OCM) that monitor native and alien wavelengths alike; as well as dynamic WSON restoration that also support both native and alien wavelengths. All Apollo OLS capabilities are controllable through Muse, which supports both Web UI human interfaces, and a machine-to-machine northbound T-API based on ONF standards.

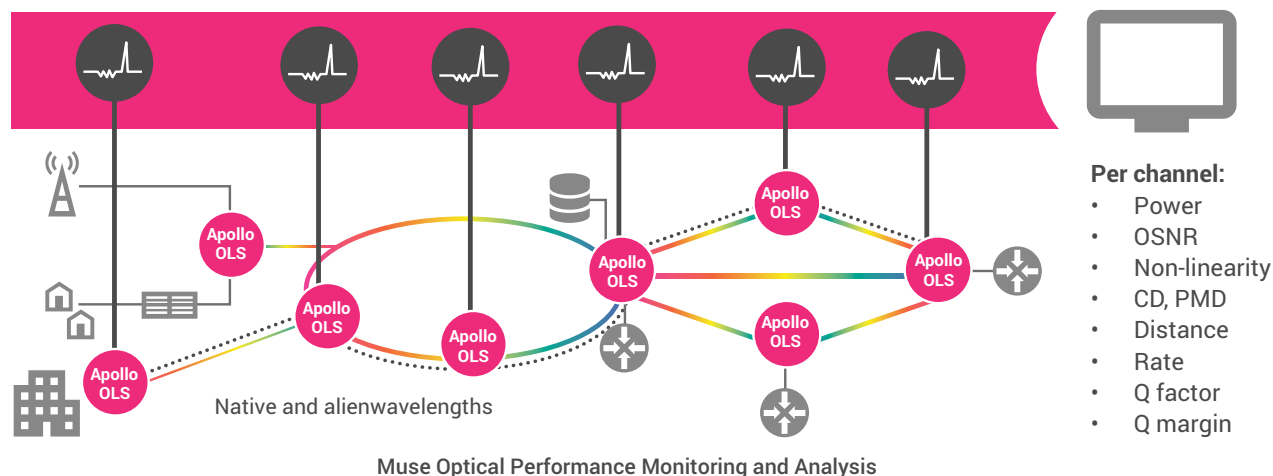
Apollo Open OLS Capabilities

- Alien wavelengths
- Alien spectral pipe
- Spectrum slicing ("virtual optical networks")
- Dynamic WSON restoration
- Optical performance monitoring
- OTDR fiber health management



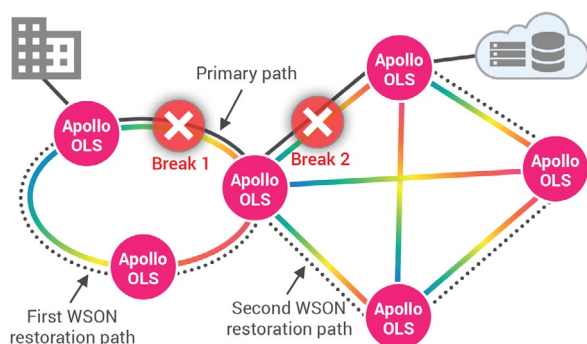
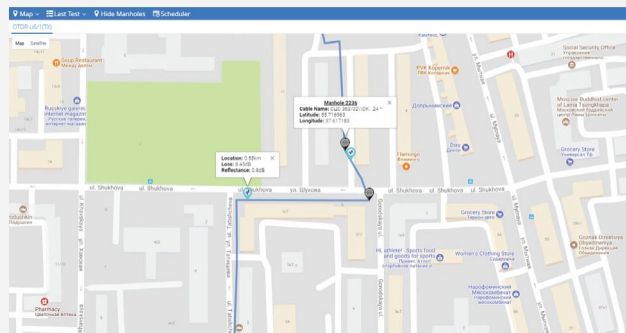
Alien Wavelength Management and Performance Monitoring

Muse SDN Domain Orchestrator provides lifecycle management and automated control for all Ribbon network solutions; with a subset of its capabilities it acts as an Apollo OLS controller. All Muse functionality also extends to alien wavelengths, for provisioning lightpaths, dynamic wavelength rerouting for fiber failures, and optical performance analysis. This last capability covers optical power, OSNR and other parameters, and displays historical trends to quickly identify potential problems before they become service affecting.



Fiber Health Management

Muse also supports OTDR (optical time domain reflectometry) to monitor the physical health of a fiber, including the integrity of all splices along a fiber's path. In the event of a fiber cut, OTDR can detect the location of the cut to within a few meters. This can be combined with GPS systems to dispatch repair crews with pinpoint accuracy.



Dynamic Restoration

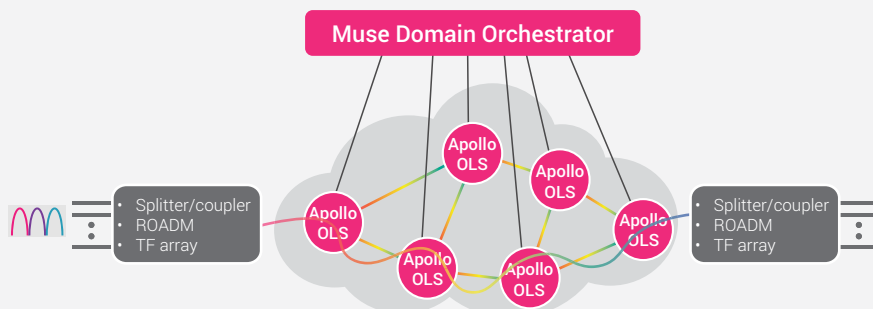
In the event of a fiber failure, Apollo OLS uses Wavelength Switched Optical Network (WSON) signaling to reroute wavelengths dynamically to restore services. This can be applied agnostically to both native and alien wavelengths. In the future, this capability will shift to centralized SDN control.

New Service Revenues through Alien Spectral Pipes and Spectrum Slicing

One of the innovations of Apollo's open OLS is extending the concept of alien wavelengths to alien spectral pipes and spectrum slicing. These open the door to new ways to monetize the optical network.

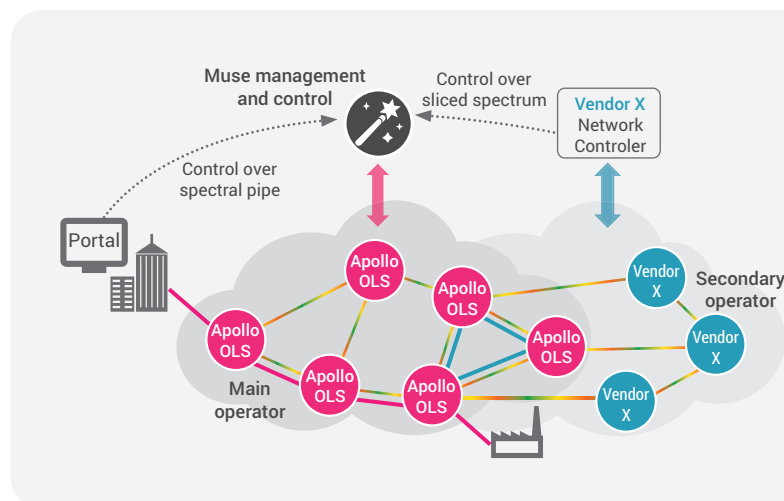
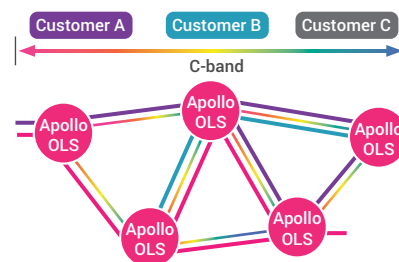
With **alien spectral pipes**, an end-user customer is assigned a point-to-point spectral pipe through Apollo OLS, over which that user can transmit multiple wavelengths based on their particular needs. End-customers may be large enterprises, data center operators, or even other network operators, who require a lot of bandwidth and want to manage its usage independently.

WSO can be applied to the entire spectral tunnel to guarantee availability, and Ribbon management systems can monitor the individual wavelengths to exercise power and gain control.



Apollo Open Optical Networking

Spectrum slicing is analogous to a “virtual optical network” and takes this concept a step further. Here the end-customer is assigned spectrum to use throughout an Apollo open OLS network. Not only can the customer run their own wavelengths over this spectrum (as in alien spectral pipes) but they can also have virtual control of the ROADMs to route these wavelengths as needed. This allows carrier of carrier applications that maximize optical network investments.



Examples

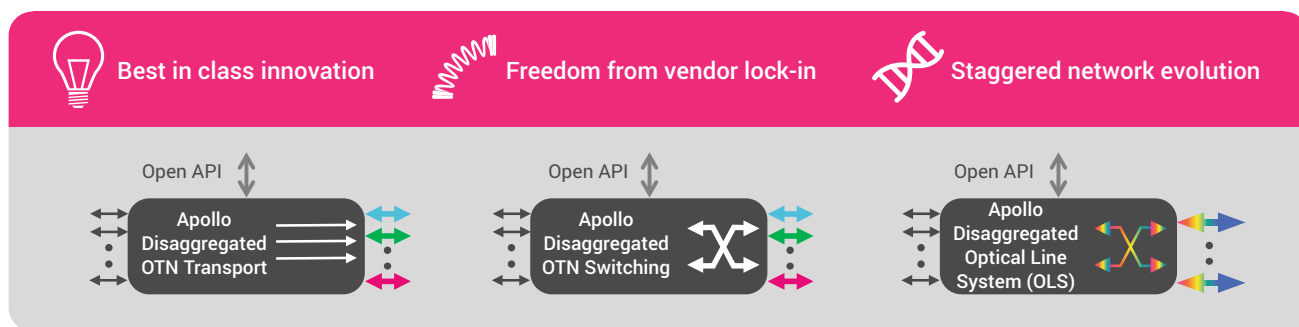
- Alien Spectral Pipe – An Enterprise uses the **pink spectrum** to build its own private optical network links.
- Spectral Slicing – The main operator acts as a CoC. It provides the **blue spectrum** to another operator that wants to extend its coverage without adding facilities.

Telco and Data Center Deployments

Apollo supports both telco and data center compatible platforms that for instance have different cabinet depth and airflow configurations. This allows deploying Apollo disaggregated solutions with great flexibility across a mix of environments, which is becoming more commonplace.

Summary

Ribbon supports both partially and fully disaggregated optical networks based on OpenConfig and OpenROADM open and standard APIs, unleashing Apollo's ability to deliver unique benefits in multi-vendor networks. These include high performance transport that transmits 400GbE clients further than any competitor approach, OTN switching that revolutionizes delivery of L1 business services, and an optical line system that elevates alien wavelengths to alien spectrum and spectrum slicing.



About Ribbon

Ribbon Communications (Nasdaq: RBBN) delivers communications software, IP and optical networking solutions to service providers, enterprises and critical infrastructure sectors globally. We engage deeply with our customers, helping them modernize their networks for improved competitive positioning and business outcomes in today's smart, always-on and data-hungry world. Our innovative, end-to-end solutions portfolio delivers unparalleled scale, performance, and agility, including core to edge software-centric solutions, cloud-native offers, leading-edge security and analytics tools, along with IP and optical networking solutions for 5G. We maintain a keen focus on our commitments to Environmental, Social and Governance (ESG) matters, offering an annual Sustainability Report to our stakeholders. To learn more about Ribbon visit rbbn.com.

Contact Us

Contact us to learn more about Ribbon solutions.