TECHNOLOGY BRIEF

Delivering a Transformative Network Architecture with XR Optics

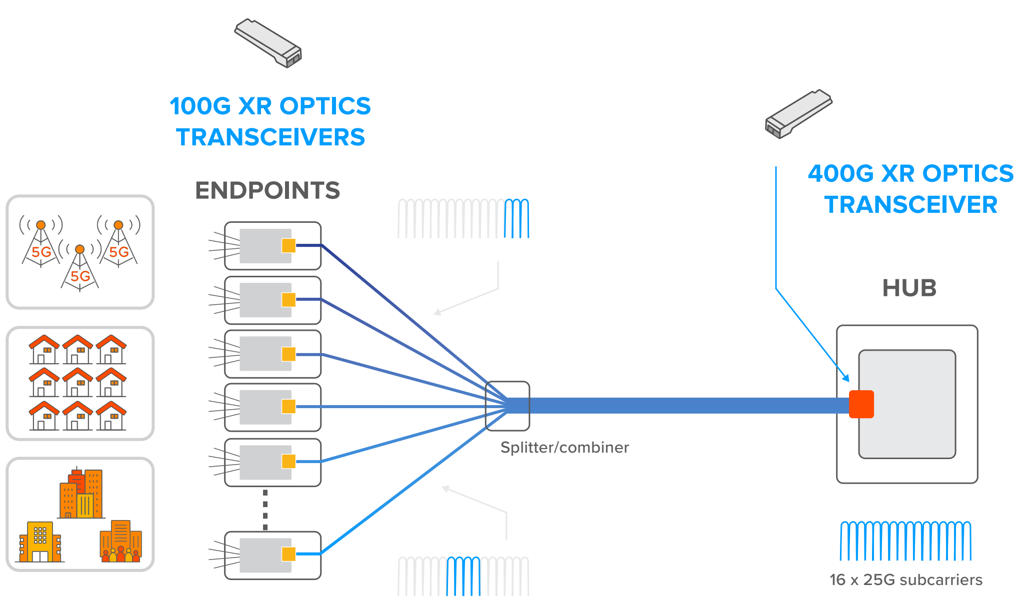
Since the inception of optical networking, there has been a significant misalignment between actual network traffic patterns and the technology used to transport that traffic. Network traffic patterns, particularly in metro networks, are overwhelmingly hub and spoke, with numerous endpoints consuming traffic that is aggregated by a small number of hub locations. In contrast, optical connectivity solutions have been implemented using strictly point-to-point technology, where each end of the connection is required to operate at the same speed (1G, 10G, 25G, 100G, etc.). The result is an extremely inefficient transport architecture that requires large numbers of bookended transceivers, as well as numerous intermediate aggregation devices to “up-speed” traffic flows.

XR optics is the next major inflection point in optical transceiver technologies. XR optics utilizes digital signal processing to subdivide the transmission and reception of a given wavelength spectrum into a series of smaller-frequency channels called digital subcarriers. These digital subcarriers can be independently modulated, managed, and assigned to different destinations, enabling the industry’s first scalable point-to-multipoint, direct low-speed to high-speed optical transceiver connectivity.

A single 400G XR optics hub module generates 16 x 25 Gb/s digital subcarriers. One or multiple digital subcarriers can be combined and assigned to a specific destination to provide the required bandwidth. XR optics transceivers are designed to be equipped into a wide range of networking equipment, including Ethernet switches, routers, wireless baseband processing systems, cable/MSO aggregation platforms, packet switch ports, passive optical network (PON) headend aggregation systems, and data center servers and switches.

XR optics also meets most common standards for other coherent pluggable optics like 400G ZR, including physical form factor (e.g. QSFP-28, CFP-2, QSFP56-DD, OSFP) and network management.

The breakthrough architectural approach of XR optics has major implications across access, aggregation, and metro optical networks. Benefits include a significant reduction in total cost of ownership (up to and in some cases more than 70%), dramatic network simplification, and an unprecedented level of network flexibility.



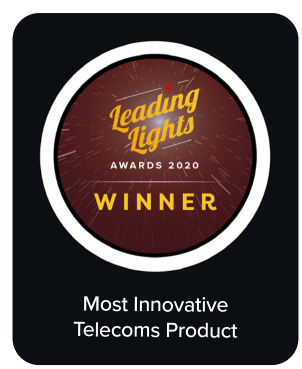


Figure 1: *Direct low-speed to high-speed optical interconnectivity with XR optics*

The Attributes of XR Optics

There are three key attributes that make XR optics transformational and unique among coherent pluggable solutions:

- **Direct Low-speed to High-speed Optical Interconnectivity**: For the first time in the optical industry, XR optics enables one or multiple low-speed transceivers to directly connect to a high-speed transceiver, breaking the bookended transceiver paradigm. Any XR optics transceiver operating at N x 25 Gb/s (where N = 1 to 16) can communicate directly with any higher-speed transceiver that is operating in M x 25 Gb/s increments (where M = 1 to 16). For example, a 25 Gb/s XR optics module deployed as an endpoint (spoke) can be connected directly to a 400 Gb/s XR optics module at a hub site (Figure 1).
- **Point-to-multipoint Interconnectivity**: While all coherent transceivers operate in point-to-point configuration, only XR optics leverages cost-effective splitter/combiner optical infrastructure to provide point-to-point and point-to-multipoint logical connectivity over hub-and-spoke, ring, and chain/linear physical fiber topologies and over a fiber pair or single-fiber infrastructure. With a common granularity of 25 Gb/s for each subcarrier, a single XR optics hub transceiver can simultaneously assign one or more N x 25 Gb/s subcarriers to one or multiple destinations. The capacity of an endpoint (spoke) can be easily and remotely increased by assigning more digital subcarriers without network re-engineering or any traffic disruption to the rest of the spokes in the network.

  Costly and time-consuming truck rolls can also be eliminated as it is no longer necessary to swap out the transceiver just because the bandwidth expanded from 25G to 50G on a link, as an example.

  Additionally, XR optics enables a consistent and multi-generational network architecture based on a common "currency" where both hub and leaves (endpoints) share the same building blocks – increments of 25G. This allows hub and leaves to be upgraded to a new generation of XR modules independently. For example, hub sites can be seamlessly upgraded to 800G XR optics without the need to upgrade any of the leaves, thus decoupling nodal upgrades from network-wide upgrades. This allows network operators to maximize ROI and ensure a smooth and cost-effective new technology introduction into the network.
- **Flexible End-to-end Management**: XR optics supports embedded communication channels to provide a complete and thorough management system between all XR optics modules (hubs and spokes). This management system facilitates bandwidth allocation and a connectivity matrix between destinations, as well as managing alarms and network status, thus allowing the XR optics modules to act as a subnetwork with a much larger network configuration. As a result, XR optics are host agnostic and can be plugged into any optical or packet layer network element, including WDM systems, switches, and routers, while being managed as a standalone optical layer. In addition, XR optics can also be managed via standard CMIS/APIs if supported by the host element (Figure 2).

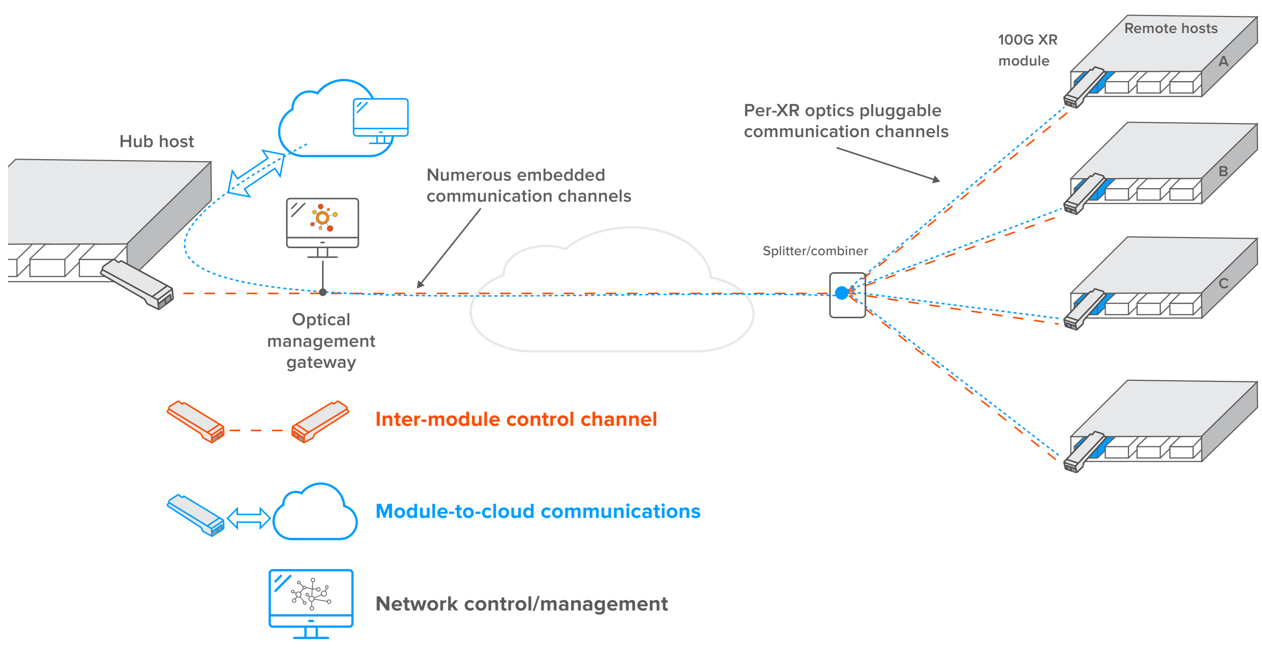


Figure 2: *XR Optics flexible end-to-end management*

The Impact of XR Optics

The unique attributes of XR optics translate into lower costs, easier upgrades, and:

- **A Significant Reduction (from 40% to +70%) in TCO**: As XR optics allows one or multiple low-speed transceivers to connect directly to a high-speed transceiver in a point-to-multipoint configuration, a significant reduction in TCO can be achieved. This is due to an immediate and massive reduction, by approximately 50%, of the number of optical transceivers and network elements in the network (from 2 x N to N + 1, where N is the number of endpoints), and the removal of numerous Layer 1 and Layer 2 platforms for traffic aggregation. Furthermore, XR optics maximizes router/Layer 3 efficiency, density, and simplicity by replacing large numbers of low-speed ports with far fewer and more-efficient high-speed ports. Additional CapEx and OpEx (power consumption, footprint, sparing costs, etc.) reductions can also be achieved by eliminating intermediate aggregation sites and their related costs. A network analysis performed on a national service provider in the United States revealed that XR optics can lead to a total cost of ownership (TCO) savings of over 70% in a five-year time period.
- **Multi-generational Network Architecture**: In addition to the significant reduction in CapEx and OpEx , XR optics enables a multi-generational network architecture. The unique ability for low-speed transceivers to communicate directly and simultaneously with a high-speed transceiver at the hub eliminates the situation where a single site upgrade triggers the need for a network-wide upgrade. It is widely known that network-wide upgrades (all nodes/links) require a significant capital investment, are labor-intensive, and often result in inefficient utilization of bandwidth where low bandwidth-consumption sites are provided with capacity significantly in excess of actual demand. For the first time in the industry, XR optics decouples node upgrades from network-wide upgrades, enabling certain spans/links or nodes (hubs or spokes) to be upgraded to higher capacity while the rest of the network remains unimpacted, thus aligning CapEx with actual capacity demands.

  For example, hub sites can be seamlessly upgraded to 800G XR optics without the need to upgrade any of the spoke locations. Similarly, if a higher-speed router is needed at any location due to the increase of aggregated traffic at that specific location, only that fiber span (end of the fiber) needs to be upgraded, while the other locations and fiber spans remain the same. The entire network becomes a combination of two XR optics pluggable transceivers (hub and spoke). This dramatically simplifies network planning and operations and reduces costs.
- **Dynamic Capacity Allocation**: XR optics enables a consistent network architecture based on a common "currency" of 25 Gb/s digital subcarriers between hub and spoke locations. Utilizing 25 Gb/s subcarriers enables more dynamic and rapid allocation of capacity in the network without complex planning and time-consuming truck rolls. Capacity can be allocated easily across the network permanently or for a certain period of time, and this allocation can be manually performed or triggered by software automation. XR optics breaks the limitations and restrictions where a service interface is bonded to a specific or a predefined traffic pattern by enabling dynamic and software-based allocation of the capacity quickly and throughout the network.

Conclusion

With XR optics, network operators now have an opportunity to reimagine their network architecture in the era of 5G, fiber deep networks, and cloud connectivity. The technology's dramatic cost reduction as a result of significant network simplification, multi-generational upgradeability, and dynamic capacity allocation anywhere in the network make XR optics truly transformative for network operators. XR optics tackles some of the chronic challenges of today's optical networks by eliminating the excessive and underutilized capacity created from bookended optical transceiver connections.

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