Transforming Aggregation Network Architecture with XR Optics

XR optics will offer fiber-to-the-home providers improved coherent-level capacity, reach and management performance with flexible deployment over point-to-point or point-to-multipoint and single- or dual-fiber architectures.

By Fady Masoud / *Infinera*

The world is on the verge of the wide-scale deployment and commercialization of 5G. This new fifth-generation wireless standard is expected to be 100 times faster than the existing 4G network, demanding a tenfold increase in access network capacity in addition to five to 10 times the number of endpoints. A network operator's challenge of traffic aggregation is far from becoming history – it will be exacerbated by this unprecedented demand for capacity, unless a new, disruptive, 5G-era–ready technology is used.

This challenge has existed since the inception of optical networking because of a significant misalignment between actual traffic patterns and the technology that transports traffic. Network traffic patterns, particularly in metro networks, are overwhelmingly hub and spoke (numerous endpoints generate traffic aggregated by a small number of hub locations).

In contrast, optical connectivity solutions are implemented using strictly point-to-point technology as depicted in Figure 1. The result is an extremely inefficient transport architecture that requires large numbers of bookended transceivers and numerous intermediate aggregation devices to "up-speed" traffic flows. But this is about to change thanks to XR optics.

The innovative technology is expected to transform how optical networks are designed, operated and evolved. XR optics utilizes digital signal processing to subdivide the transmission and reception of a given wavelength spectrum into a series of low-frequency channels called digital subcarriers. They 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. Any XR optics transceiver operating at N x 25 Gbps (where N = 1 to 16) can communicate directly with any higher-speed transceiver that is operating in M x 25 Gbps increments (where M = 1 to 16) as depicted in Figure 2.

XR optics is a superset coherent optical module that works in point-to-point or point-to-multipoint applications over single- or dual-fiber architectures. Additional unique characteristics include remote management capabilities and full topology awareness.

XR optics technology comes at a particularly good time for network operators struggling to cost-effectively manage the impending tidal wave of traffic coming from applications such as 5G, fiber deep, and cloud-based business services – and their impact will be significant.

FLEXIBLE CAPACITY UPGRADES

Infinera recently announced that American Tower completed a live network demonstration of XR optics. The trial specifically highlighted its ability to transmit coherent capacity levels

over an existing PON infrastructure, preparing the network for 5G expansion and beyond.

The trial also highlighted one of the key capabilities of XR optics – its flexible deployment options, including deployment over a fiber pair or a single fiber, also known as single fiber working. Passive optical networks (PON) and often wireless towers are connected over a single fiber. In these cases, data can be sent simultaneously; one single-mode fiber can transmit and receive traffic flows in both directions from each endpoint.

The trial underscored XR optics' ability to be inserted into existing single-fiber networks, such as PONs used for wireless backhaul, by leveraging current building blocks such as PON filters and splitters. Existing PON traffic and new traffic carried over XR optics can coexist on the same infrastructure, allowing network operators to maintain the current operational model while enabling a whole new level of scalability and flexibility in the network.

> A recent trial highlighted the ability of XR optics to transmit coherent capacity levels over an existing PON infrastructure, preparing the network for 5G expansion and beyond.

One of XR optics' key attributes is its dynamic capacity assignment: capacity at remote sites (e.g., cell towers) can be increased easily in 25G increments without truck rolls by simply assigning additional digital subcarriers. Figure 3 depicts a typical deployment of XR optics over existing gigabit PON (GPON) or even XGS-PON infrastructure.

SINGLE-FIBER OPERATION

When deploying over a fiber pair, an XR optics coherent pluggable at the hub site generates 400 Gbps of capacity consisting of 16 x 25 Gbps digital subcarriers. A passive splitter sends the digital subcarriers to each remote site or leaf. Through the management system, each coherent pluggable at the remote site (e.g., cell tower) tunes into

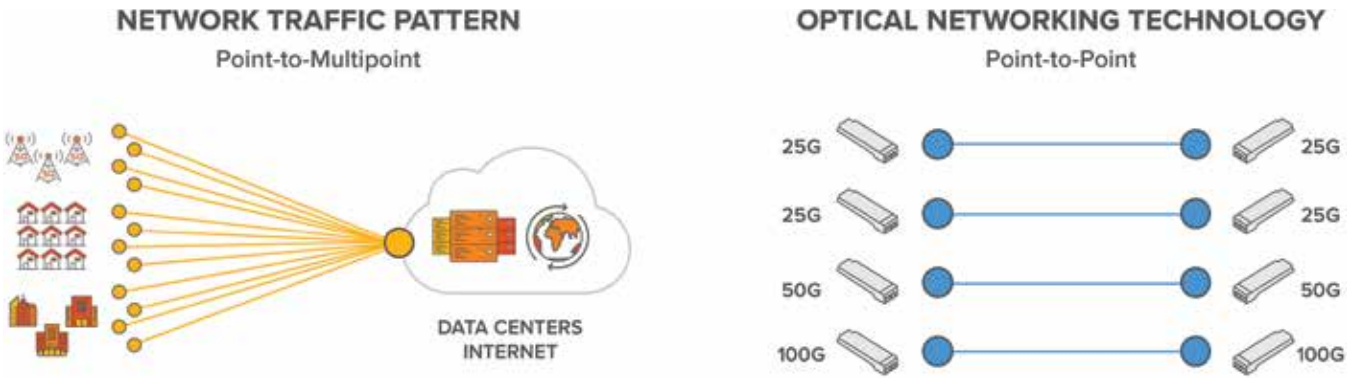

Figure 1: Point-to-point optics vs. hub-and-spoke traffic

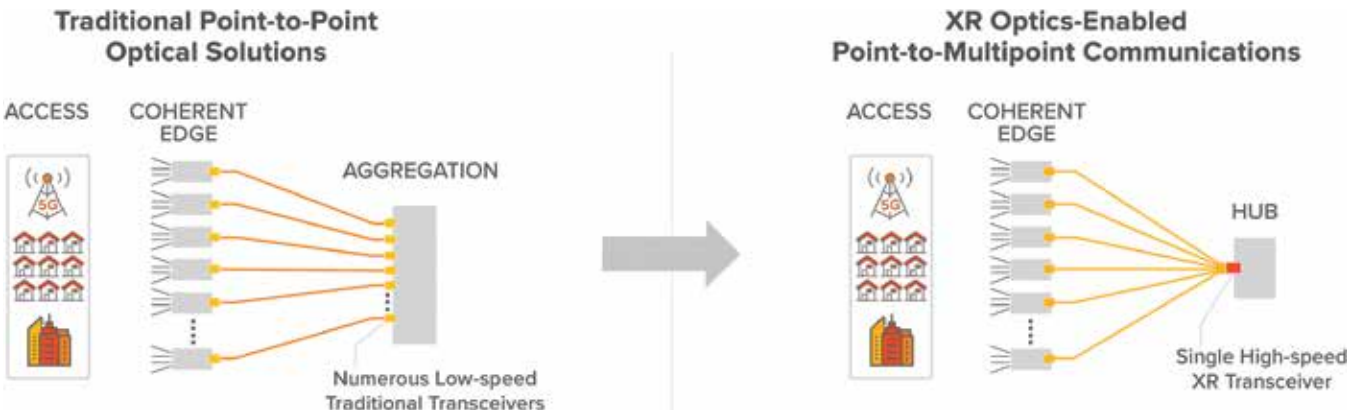

Figure 2: XR optics point-to-multipoint connectivity

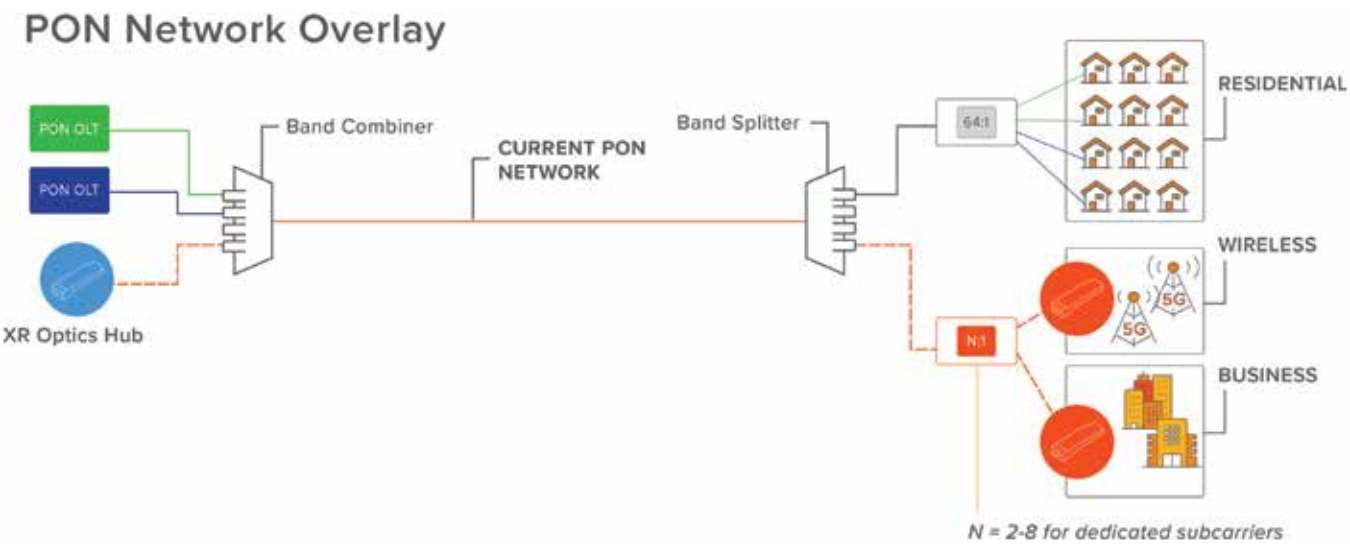

Figure 3: Typical deployment of XR optics over an existing PON infrastructure

the one or multiple subcarriers it has been assigned – for example, digital subcarriers 5, 6, 7 and 8.

Once locked into the assigned digital subcarriers, the XR optics coherent pluggable at the remote site sends back to the hub, on the second fiber, digital subcarriers that match the same lineup as the received subcarriers, 5, 6, 7 and 8 in the example illustrated in Figure 4.

If only one fiber is used for both transmitting and receiving (single fiber working), a Y-cable or an optical circulator can be used at each end of the single-fiber link, enabling upstream (remote sites to hub) and downstream (hub to remote sites) optical signals being transmitted over different frequencies to use the same single fiber, resulting in bidirectional traffic. Typically, an optical circulator provides approximately 10 percent better performance than a Y-cable.

The XR optics coherent pluggable at the hub site frees up the specific part of the spectrum by not transmitting the digital subcarriers dedicated to traffic received from the remote site, or upstream traffic. As a result, downstream and upstream digital subcarriers can flow in both directions on the same single fiber, as depicted in Figure 5.

Traffic can be symmetrical – the same number of digital subcarriers is used for downstream and upstream traffic flows, or asymmetrical – more digital subcarriers are used in one direction to meet the demand of specific traffic profiles, such as video broadcasting. Both fiber pairs and single fibers can be connected simultaneously to a single XR optics coherent pluggable at the hub.

The benefits of overlaying XR optics on an existing PON infrastructure:

- **Significantly more capacity and enhanced scalability:** Whether it's the current generation of PON, such as XGS-PON with 10G of total capacity or the next generation, such as NG-PON2 with 40G of total capacity, PON solutions have limited total capacity and reach. Total capacity is defined by the bundling of 10 Gbps

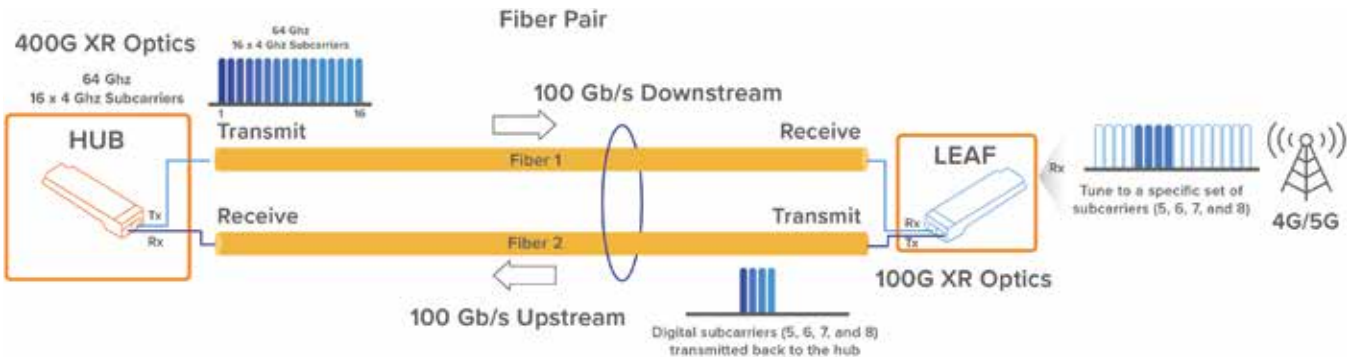

Figure 4: XR optics over a fiber pair

wavelengths, and reach is limited by non-return-to-zero (NRZ) modulation performance.

XR optics brings coherent-level performance to PON networks, providing significantly more capacity – 40x compared to XGS-PON and 10x compared to NG-PON2 – with a total of 400 Gbps that can be assigned to different endpoints in 25G increments.

Remote site capacity can be increased easily and remotely, without site visits. This enhanced scalability is key for 5G deployments because it is difficult to forecast true traffic growth. Hub capacity is no longer burdened by the bundling of numerous 10 Gbps wavelengths. XR optics' scalability from 25 Gbps to 400 Gbps enables network operators to cope with unpredictable traffic demand without network disruption or significant spend in capex.

- **Smooth evolution path:** XR optics' ability to coexist with existing PON networks allows network operators to smoothly scale their networks by migrating traffic to XR optics based on their own business and operational needs.
- **Increased ROI:** Adding XR optics to an existing PON infrastructure leverages existing equipment such as filters, amplifiers and splitters, allowing a maximized return on investment. Traffic carried over an existing PON can coexist with traffic carried over XR optics, enabling network operators to smoothly shift the current traffic to XR at their own pace and based on their own business and operational requirements.

XR optics also provides a disaggregated growth model in which the hub side can be upgraded from 400G to 800G+ in the future, with no changes to the leaf optics on the other side of the network. It is the industry's first multigenerational optics between high-speed and low-speed transceivers.

- **Expanded coverage:** The ability to reach remote sites using PON is dictated by the maximum distance between the splitter and the optical network terminal, which is around 25 km. XR optics uses a 16QAM modulation scheme that enables far better reach – hundreds of kilometers. This enables network operators to tap into new addressable markets beyond their current geographical presence.

> Overlaying XR optics on existing PON infrastructure has multiple benefits, including more capacity, enhanced scalability, a smooth evolution path, increased ROI and more.

XR optics brings coherent-level capacity, reach and management performance to existing networks with flexible deployment over point-to-point or point-to-multipoint and single- or dual-fiber architectures. PON network operators now have a cost-effective, flexible and highly scalable solution to cope with the relentless demand for bandwidth. ❖

Fady Masoud is a director of solutions marketing at Infinera.

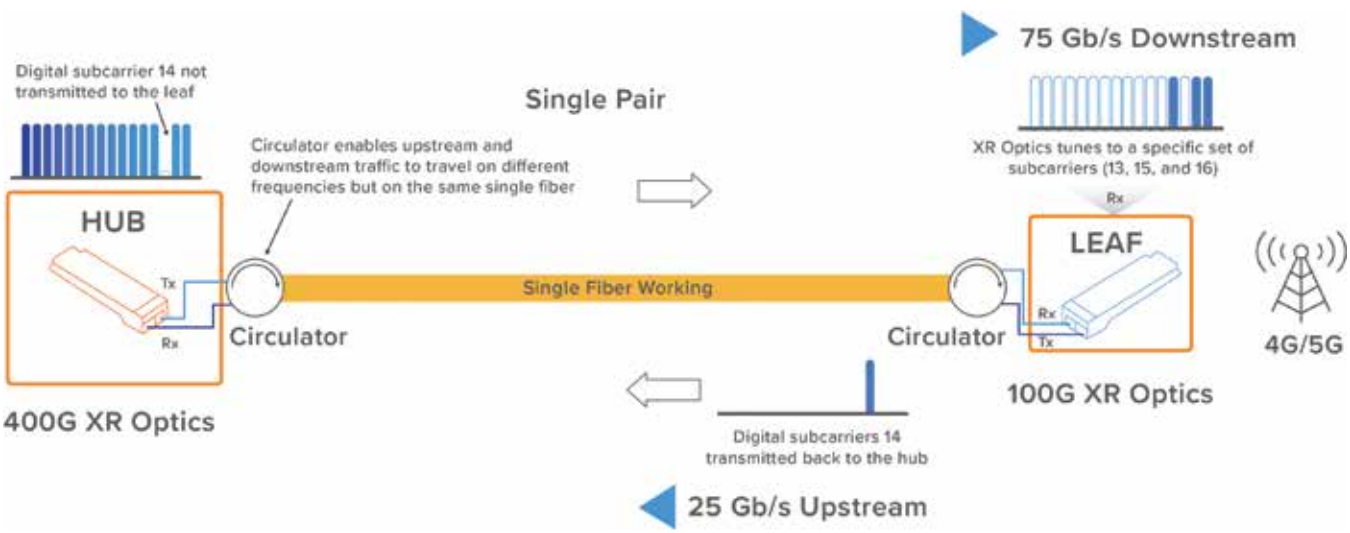

Figure 5: XR optics over single fiber