Independent market research and competitive analysis of next-generation business and technology solutions for service providers and vendors

HEAVY READING

WHITE PAPER

The Path to Open and Disaggregated FTTx

A Heavy Reading white paper produced for Sterlite Technologies Limited

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INTRODUCTION

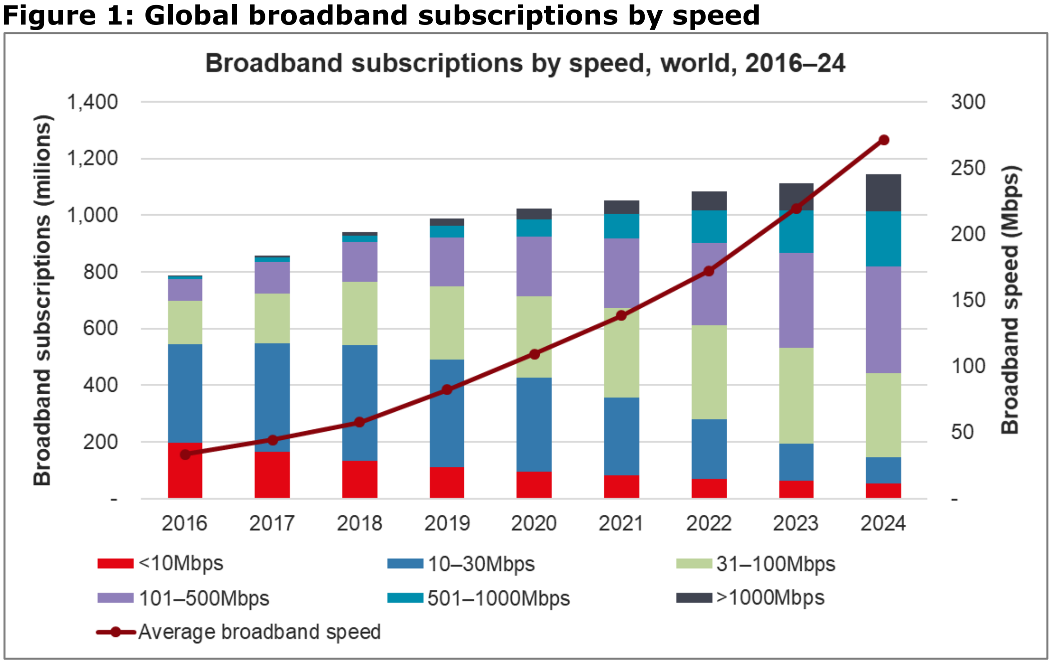
Operators face continued increases in traffic, slow revenue growth, and competitive pressures to invest in and innovate for emerging cloud and 5G-related applications. As a result, they are increasingly looking to hyperscaler-led innovations, including software-defined networking (SDN), virtualization, and disaggregation. Due to size and complexity, fiber access networks have emerged as an area of particular interest and promise for driving lower network costs and delivering advanced services across the residential, business, and wholesale markets.

The separation of passive optical network (PON) network elements into open hardware and software components under SDN control is at the heart of the disaggregated and open architecture. This white paper begins with an overview of the drivers leading operators to evaluate disaggregation for their next-generation fixed access networks. The paper then presents the value proposition for FTTx disaggregation and programmability and details the technology, standards, and ecosystem advances that will enable mass-market adoption. Throughout the paper, Heavy Reading points to specific industry examples to illustrate industry progress in FTTx disaggregation.

FIXED BROADBAND DRIVERS/TRENDS

Global broadband speeds continue to accelerate. Omdia estimates that global average broadband speeds hit 50Mbps in 2017. As shown in **Figure 1**, they are forecast to exceed 270Mbps by 2024. These are global averages; in developed regions, data rates will be much higher. By 2024, for example, the average broadband speed in Hong Kong is expected to hit 460Mbps.

Figure 1: Global broadband subscriptions by speed



Source: Omdia, Consumer Broadband Subscription and Revenue Forecast: 2019–24, 2020

While continued growth in subscriptions and increased hunger for bandwidth are good news for operators on the surface, these factors do not generate commensurate growth in operator services revenue. Omdia forecasts fixed broadband services revenue in the top 20 global countries will grow from $263bn in 2020 to $299bn in 2025 at a CAGR of 2.6%. This is a rate far below the expected growth in broadband speeds and far below expected network traffic growth during that time. While revenue is forecast to grow modestly, average revenue per user (ARPU) for fixed broadband services is expected to decline at a 1.8% CAGR from 2019 to 2024 based on Omdia's June 2020 forecast.[*] At the same time, global operator capex is expected to rise during this period, increasing at a 2.5% CAGR.[†] Constrained revenue translates to constrained ability to spend and imposes two universal mandates on operators:

- Address continued network growth in the most efficient way possible and at the lowest possible costs.
- Create profitable new revenue streams to boost growth, either with new services or by entering new markets.

THE RISE OF OPEN AND DISAGGREGATED NETWORKS

Broadband equipment suppliers have an essential role to play as partners in addressing these network challenges, but many operators are frustrated by a dynamic that has only strengthened over the past decade. In a trend that parallels the radio access network (RAN), the global fixed access network has become highly concentrated among just three large suppliers. Omdia estimates that 80% share of the $7.8bn global fiber and DSL broadband equipment market is concentrated among Huawei, ZTE, and Nokia. Concentrated vendor share limits operators' freedom to choose and innovate within fixed access.

Operators are increasingly looking to open and disaggregated networking in broadband access, a trend that has also gained traction in other large networking segments with concentrated market share. Heavy Reading defines disaggregation in networking as follows:

The separation of networking equipment into functional components and allowing each component to be individually deployed:

- *Ideally, provided in the smallest form-factor capable of delivering a specific function.*
- *Equipment should be self-contained, require no additional common equipment to operate, and incorporate open APIs to enable SDN control.*

Significantly, the terms "disaggregation" and "white box" are not synonymous. Rather, white box is a specific subset of disaggregation that requires open specification hardware (defined in groups including the Open Compute Project [OCP] and Telecom Infra Project [TIP]) that is produced by different contract manufacturers. White box implementation has its own benefits and challenges, but the main point is that disaggregation is not a one-size-fits-all solution in the market.

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[*] *Total Fixed Broadband Subscription and Revenue Forecast: 2020–25*, Omdia, June 2020
[†] *Communications Provider Revenue & Capex Forecast Highlights: 2019–2024*, Omdia, August 2019

Benefits of open and disaggregated networks

Heavy Reading sees the following as the primary benefits driving the open and disaggregated networks:

- **Break vendor-proprietary lock-in:** Historically, fixed broadband systems have been closed and proprietary, with PON and DSL hardware, operating system software, and management software all supplied by the same vendor. Also, as noted, the number of fixed suppliers has declined as the broadband market has matured, leaving just three suppliers accounting for 80% of the multibillion-dollar annual equipment revenue. Disaggregating broadband hardware, software, and management/control provides the industry an opportunity to break this lock, in part by lowering the barriers to entry for new entrants. New software suppliers, for example, can build PON systems by investing R&D exclusively in software development and using high volume hardware designed and produced by other ecosystem partners.
- **Reduce network costs:** The access network accounts for a large share of a Tier 1 operator's typical network spend, so it is a segment of great attention when it comes to costs. Opening the fixed access network presents opportunities for new entrants (as described above), leading to greater competition and thus lower pricing through market forces. But there are other factors in disaggregated architectures that contribute to lower costs as well. Disaggregating software components from the underlying hardware opens new opportunities for running on low cost white box hardware produced in high volumes. Furthermore, sharing general purpose compute across multiple functions (i.e., not dedicated solely to FTTx) provides additional cost savings through greater efficiency.
- **Offer new services and monetization opportunities:** Broadband ARPUs vary greatly by country, but the unmistakable trend is that ARPUs (whatever their starting point) are trending downward. Network operators, universally, see a mandate to increase revenue. With broadband subscription growth slowing, this growth must increasingly come from new services and new markets. For fixed broadband, revenue opportunities span residential, enterprise, and 5G backhaul services. Disaggregation alone does not result in new services, but open and disaggregated access networks open the door to high customization and differentiation through in-house developments as well as third-party contributions.
- **Enable faster innovation with diverse ecosystem:** Speed of innovation is a defining characteristic of the hyperscalers, and telecom operators have been adopting hyperscaler best practices in hopes of emulating their successes. Disaggregation, open APIs, open ecosystems, and open source development are key components. One goal is to press the accelerator on telecom innovation, in part to generate new revenue (as noted above). Significantly, as operators increase their reliance on nontraditional suppliers, they expect that network innovation will increasingly be driven by nontraditional suppliers as well.

Status update: Access

Over the past several years, open disaggregation concepts—including SDN and network functions virtualization (NFV)—have moved to commercial adoption in multiple networking areas, including data center networks, IP/MPLS, optical infrastructure, the mobile core, and enterprise software-defined wide-area networks (SD-WANs), among others. Access was not the first focus area for open and disaggregated innovation in fixed or mobile networks due primarily to the greater size (e.g., number of nodes) and complexity relative to other segments, such as data center interconnection among a handful of nodes. However, operators have repeatedly told Heavy Reading—through surveys and one-on-one interviews—that, while not the first, the access network holds the greatest long-term potential for disaggregation precisely because of this size and complexity. Capex and opex savings associated with tens of nodes in a core network is good but applying those savings to thousands of nodes across an access network is much better.

With early SDN proof points and hands-on experiences gained from other domains, operators are actively investigating access networks. The trend has advanced significantly over the past 12 months, with major operators engaging in proofs-of-concept (POCs) and lab trials. Prominent examples include AT&T, Deutsche Telekom, and Telefónica, among others.

It is too early to predict the extent to which white box solutions will replace traditional PON optical line terminal (OLT) solutions. However, several service providers have announced their interest in more open approaches. In a 2019 white paper making the case for an open access architecture, Telefónica stated:

> *This is a necessary evolution in order to deploy 5G, XGS-PON networks and CPEs in a sustainable way. Our access network will be transformed into an open and standard based access network. Natively built as a software-based solution with multivendor components integrated in a whitebox node.* *

Technology and market challenges

Disaggregation is relatively new to telecom networks generally, and FTTx is still in a pre-commercialization stage. In this section, Heavy Reading details the main hurdles that must be overcome to move to mass-market adoption:

- **Developing technology, standards, ecosystem:** Technology, standards, and ecosystems are interrelated, and maturity across all three will be required before operators migrate to disaggregation en masse. That said, the industry has advanced in the past 12 months, with ecosystem supplier support growing (including from application-specific integrated circuit [ASIC] vendors) and operators moving into POCs.
- **Integrating legacy networks (brownfield vs. greenfield):** Not unique to FTTx, the integration challenge exists for any new technology adoption. An early-stage solution is to run legacy and new networks in parallel (e.g., coexistence). Umbrella orchestration of both the legacy and next-gen systems is the most preferable approach—if legacy systems can support it. Ultimately, operating parallel systems is difficult to sustain operationally, so operators would need to adopt timelines for migrating fully to next-gen networks over time. This is, however, never quick.
- **Supporting operations and disaggregated networks:** The challenge stems from the fact that disaggregated systems are built from multiple hardware and software suppliers. A frequent question from operators is: Who is responsible for ensuring

* *Open Access and Edge Computing White Paper*, Telefónica, February 2019

operation of the system and stepping in when something fails? Potential solutions are emerging. One is the hybrid model of the branded white box (or "brite box") in which the brand supplier is responsible for the packaged system. Another involves systems integrator partners, such as Sterlite Technologies Limited (STL), that take on the responsibility of designing, building, and managing networks for telecom operators. As the disaggregated technology and ecosystems mature, support options will also increase in number.

COMPONENTS OF DISAGGREGATED FTTX

This section details the main software and hardware components that make up a disaggregated FTTx network.

Software components

- **SDN controller:** The SDN controller provides the centralized and automated control plane function for the data plane elements in the network. It receives and processes requests from the orchestration layer above through a standardized northbound interface (NBI), and then communicates those requests to the network elements below. In a PON network, these elements are OLTs and optical network terminals (ONTs). Southbound communication is not direct. Rather, an abstraction layer (described in more detail below) sits between the controller and the elements in order to simplify the SDN control function.
- **Hardware abstraction software:** Crucial to the open and disaggregated fixed broadband model is the insertion of a hardware abstraction layer between the SDN controller and the data plane elements. The goal of this layer is to hide the complexity of the data plane from the controller such that, regardless of what data plane is used, the controller always "sees" and communicates with an Ethernet switched network. In the SDN-Enabled Broadband Access (SEBA) reference design, the abstraction functions are labeled "drivers." In other SDN architectures, software performing a similar function is often called an adapter. For an FTTx network, drivers will be needed to support PON, XGS-PON, and NG-PON2. Other types of fixed broadband networks will need drivers for Gfast, DOCSIS, or other technologies.
- **Edge orchestrator:** The edge orchestrator is the mediation layer between the edge/access system and the service provider backend systems (e.g., operations and business support systems [OSS and BSS] and global orchestration). It communicates southbound to the SDN controller (or controllers) that manages the access/access network and northbound to the operator's backend systems. Multiple operator OSS/BSS and global orchestration frameworks must be integrated northbound for an open network. The edge orchestrator function is also called a network edge mediator (NEM) in Open Networking Foundation (ONF) SEBA terminology.
- **Open APIs:** APIs are the glue that holds together all the disaggregated FTTx components, including orchestrators, controllers, and network elements. In the absence of APIs to allow open communications among the various components, the communication between them becomes proprietary—which must be avoided in an open architecture.

Specifically, the key interface points include the following:

- Edge orchestrator-SDN controller
- SDN controller-hardware abstraction software
- Software abstraction software-forwarding plane/network elements

Many APIs are in play for these functions, including Netconf, gRPC, REST, P4, OpenFlow, Redfish, and others. Because of their size and influence, hyperscalers such as Amazon and Google have the power to make APIs de facto standards simply by adopting them. Individual telecom operators and their suppliers do not have such influence. Thus, APIs must be endorsed by open source communities (such as ONF and TIP) and traditional standards bodies (such as the Broadband Forum and European Telecommunications Standards Institute [ETSI]).

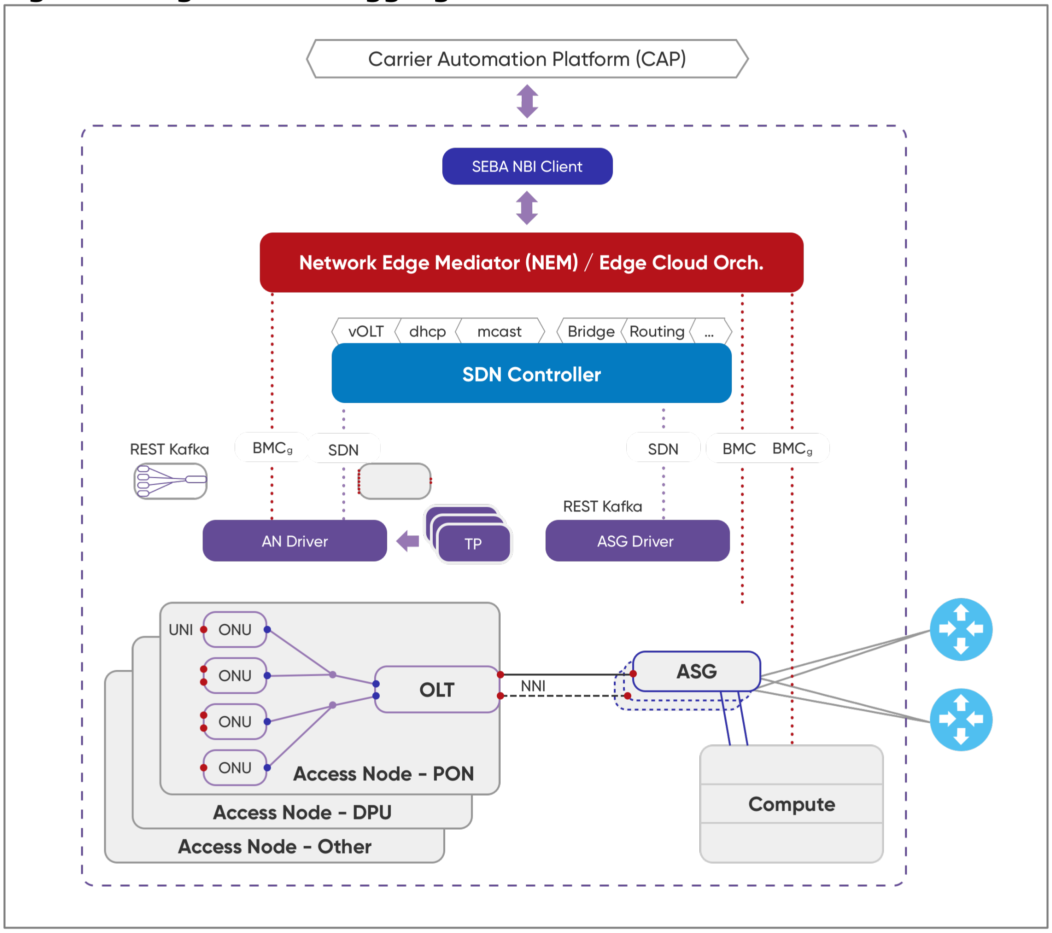
Hardware components

In the case of disaggregated FTTx, there are two main hardware elements, an OLT and an ONT, that are used in Gigabit Passive Optical Network (GPON), XGS-PON, and NG-PON2 networks:

- **White box OLT:** As in a traditional FTTx architecture, the OLT serves as the service provider endpoint and resides in a central office (CO) or an edge data center. It converts electrical signals from the service provider network to the optical signals transmitted through the PON, and it coordinates the multiplexing of the ONT devices in the network. White box OLTs are built to open specifications defined in groups (including OCP) from contract manufacturers such as Edgecore Networks, Celestica, and CIG. They use merchant media access controller (MAC) and ASIC chips from chip companies, including Broadcom and Microsemi. Hardware specifications, including port counts and data rates, will vary depending on form of PON supported.
- **White box ONT:** As in a traditional FTTx architecture, the ONT is the customer-side endpoint of a PON network that converts electrical signals from the end user's network (residential, business, or wholesale) to optical signals transmitted through the PON. Just as in the OLT model, a white box ONT is built to an open specification that can be used by multiple hardware manufacturers. Optical network units (ONUs) can also be built as pluggable (i.e., "ONT on a stick") hardware using enhanced small form-factor pluggable (SFP+) and other pluggable formats.
- **Branded white box or brite box hardware:** Beyond pure white box implementation, another deployment model exists in which OLT and ONT hardware is manufactured as in white box, but a supplier preloads its own software and brands the devices as its own. The model is a middle ground between traditional hardware and white box hardware and comes with the benefit of full support from the brite box supplier.

Figure 2 below shows a disaggregated broadband architecture based on the ONF SEBA reference design, including all of the components. FTTx (designated by the OLT and ONT elements) is the initial reference design option being built.

Figure 2: High level disaggregated broadband architecture based on ONF SEBA



Source: Open Networking Foundation, 2019

The following section provides additional details on the ONF work, as well as important work from the Broadband Forum.

Industry ecosystem support

Open Networking Foundation

SEBA is a reference design architecture for a common and modular platform for broadband access products based on open APIs, white box hardware, and open source software. Within access, the technology scope is broad and includes PON, XGS-PON, NG-PON2, EPON, future PON technologies, Gfast, Ethernet, fixed wireless, DOCSIS, and xDSL. Software elements are built to run in a containerized Kubernetes environment and include a NEM, SDN control, control applications, access node driver, and aggregation and service gateway driver. For hardware, SEBA encompasses PON OLTs and ONTs and Gfast distribution point units (DPUs) in access (with future potential for additional access elements), Layer 2/3 switches and routers in aggregation, and hardware services to host driver functions.

The SEBA reference design was published in March 2019, and operator champions include AT&T, Deutsche Telekom, NTT, and Turk Telekom.

A component of the SEBA reference design, Virtual OLT Hardware Abstraction (VOLTHA) is an open source project to create a hardware abstraction for broadband access equipment. Today, VOLTHA provides a common GPON control and management system for both white box and vendor-specific hardware devices. The upcoming introduction of access technology profiles will extend support to additional access technologies, including EPON, NG-PON2, and Gfast. On the NBI, VOLTHA works by hiding PON-level details to make the PON network appear as a programmable Ethernet switch to an SDN controller. On the southbound interface (SBI), VOLTHA uses different adapters to communicate directly with vendor-specific (i.e., proprietary) and open white box OLTs and ONTs. Additional broadband hardware types will be incorporated under VOLTHA by creating new southbound adapters.

Operator leads for VOLTHA include AT&T, Deutsche Telekom, Google, NTT, Turk Telekom, and Telefónica. VOLTHA is expected to reach production by the end of 2020 at AT&T, Deutsche Telekom, and Turk Telekom.

Broadband Forum

The Broadband Forum is addressing open and disaggregated networks through several initiatives under the "Open Broadband" umbrella. Open Broadband-Broadband Access Abstraction (OB-BBA) is an open source project that specifies NBIs, core components, and SBI adapters for virtualized broadband access functions. OB-BBA promises to pull together different access device types, including legacy implementations, under a single network. The service management and control umbrella will be exposed to management elements, including SDN management and control and element management systems.

In contrast to the virtualization-focused ONF, OB-BAA is built on the premise that disaggregation and virtualization are different steps, occurring at different paces according to operator requirements. For example, operators want to improve the time and resources required to ensure interoperability between OLTs and ONTs/ONUs from different vendors. OB-BAA supports this process without requiring virtualization of either OLTs or ONTs/ONUs. Operator participants include AT&T, BT, CenturyLink, China Mobile, China Telecom, China Unicom, and TIM. OB-BBA Release 3.0 was released in February 2020.

DISAGGREGATED FTTX USE CASES AND DEPLOYMENT ARCHITECTURES

Disaggregated FTTx use cases are the same as traditional FTTx use cases and include residential, business/enterprise, and mobile backhaul. Heavy Reading describes each briefly below.

Residential broadband

The rapid and continued increase in download speeds has driven investment in next-generation access technologies. As shown in **Figure 1** (from the ***Fixed broadband drivers/trends*** section), the global average broadband speed already exceeds 100Mbps and continues to climb. Copper broadband technologies are quickly becoming obsolete. The growing trend is to replace the copper access network altogether with fiber-to-the-building/-home (FTTB/FTTH).

Enterprise services

Like residential users, businesses also require faster and faster download speeds. One difference in enterprise services is that businesses are willing to pay more for connectivity, meaning a faster ROI for operators that offer services. An important consideration in enterprise applications will be availability and service-level agreements (SLAs), comparable to SLAs to which enterprises are accustomed in Ethernet and private line services. PON-based enterprise services make sense in converged networks and geographies in which operators can service both enterprise and residential customers using the same optical distribution network.

Backhaul

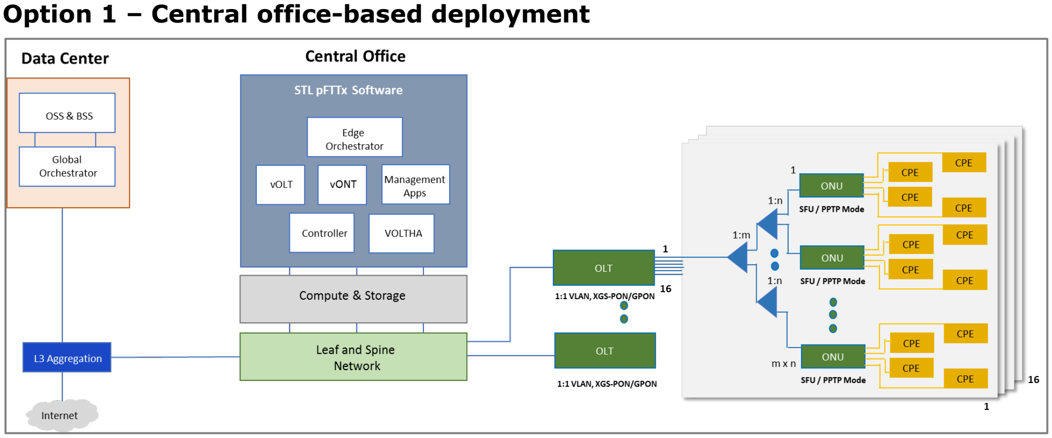
As new macro sites and particularly small cells are deployed globally to support 5G, demand for backhaul connectivity—moving data from the macro or small cell site to the mobile core—is set to skyrocket. For small cells in particular, these will be new connections that require new backhaul infrastructure to support them. As in next-gen broadband access, fiber is the first choice among operators for 5G backhaul. PON is appealing in converged networks that share residential and business services but also as an opex-saving option through the passive optical infrastructure. For 5G, in particular, high data rates are crucial, but operators are globally are investigating 10Gbps symmetrical XGS-PON as well as four-wavelength NG-PON2. The latter is particularly suited to multiservice converged networks in which separate wavelengths can be reserved for backhaul services.

Deployment architectures

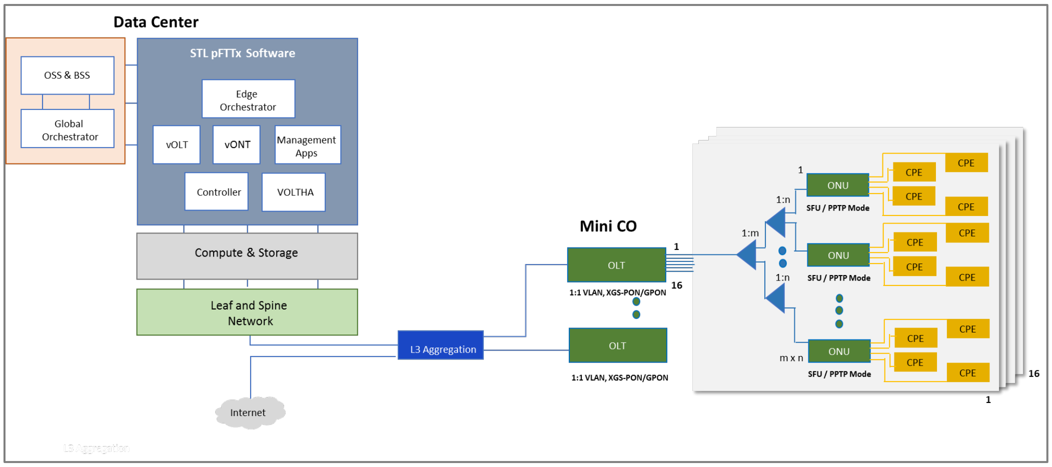
At this stage, use cases for disaggregated FTTx map closely to traditional FTTx use cases (as described above), but disaggregated FTTx differentiates in offering two major deployment scenarios: a CO scenario and a data center scenario (see **Figure 3**). Option 1 depicts an XGS-PON or GPON network in which components are disaggregated but collectively housed in a CO, suitable for CO-based edge point-of-presence (PoP) setup. Option 2 depicts a disaggregated XGS-PON or GPON in which components are distributed between the data center and a lightweight "mini CO" that contains OLT functions only, suitable for regional data center-based edge PoP setup.

Figure 3: FTTx deployment options

Option 1 – Central office-based deployment



Option 2 – Data center and mini central office-based deployment



Source: Sterlite Technologies Limited, 2020

CONCLUSIONS AND INDUSTRY NEXT STEPS

Since starting in the data center a decade ago, SDN-based open and disaggregated networks have been spreading to other areas of networking. It is not a surprise that the fixed access network has become a key area of operator focus, as access networks hold the greatest long-term potential to reap the benefits disaggregation. These benefits include the following:

- Breaking vendor-proprietary lock-in
- Reducing network costs
- Providing new services and network monetization opportunities
- Offering fast innovation cycles with diverse ecosystems

Using open and disaggregated FTTx architectures, operators can meet users' increasing bandwidth needs and pursue new opportunities across residential, business, and 5G backhaul use cases. They can also deploy both traditional and cloud-based architectures as required. Today, technology, standards, and ecosystems have matured to allow operators to move from concept to trials to commercial rollouts. A new phase of open and automated fiber access networking has begun.

ABOUT STL – STERLITE TECHNOLOGIES LIMITED

STL is an industry-leading integrator of digital networks.

We design and integrate these digital networks for our customers. With core capabilities in Optical Interconnect, Virtualised Access Solutions, Network Software, and System Integration, we are the industry's leading end-to-end solutions provider for global digital networks. We partner with global telecom companies, cloud companies, citizen networks, and large enterprises to deliver solutions for their fixed and wireless networks for current and future needs.

We believe in harnessing technology to create a world with next-generation connected experiences that transform everyday living. With an intense focus on end-to-end network solutions development, we conduct fundamental research in next-generation network applications at our Centre of Excellence. STL has a strong global presence with next-gen optical preform, fibre, and cable manufacturing facilities in India, Italy, China, and Brazil, along with two software development centers across India and one data centre design facility in the UK.