A comprehensive guide to next-gen PON decisions

Decades of FTTH deployment experience to help you create a future-ready network

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Introduction

The gigabit revolution has begun. Today, humans are creating, storing, and sharing massive amounts of data, and our digital footprints continue to grow at a stunning rate. It is estimated that, in 2020, people created 1.7 MB of data every second, and, by 2025, it is expected that over 200 zettabytes will be housed in cloud storage worldwide. This data is not only constantly growing, it is constantly flowing as it helps educate, inform, entertain, and connect people around the globe.

CommScope is committed to doing its part to keep the data flowing, and we are constantly pushing the boundaries of communications technology to help people interact and thrive in our hyper-connected world. Our experience and leadership have never been as important as they are today, when service providers are making decisions that will shape the networks of tomorrow. Among the most critical considerations for network operators is on the design and deployment of next-generation passive optical networking (PON), which delivers 10 Gbps now and continues to grow.

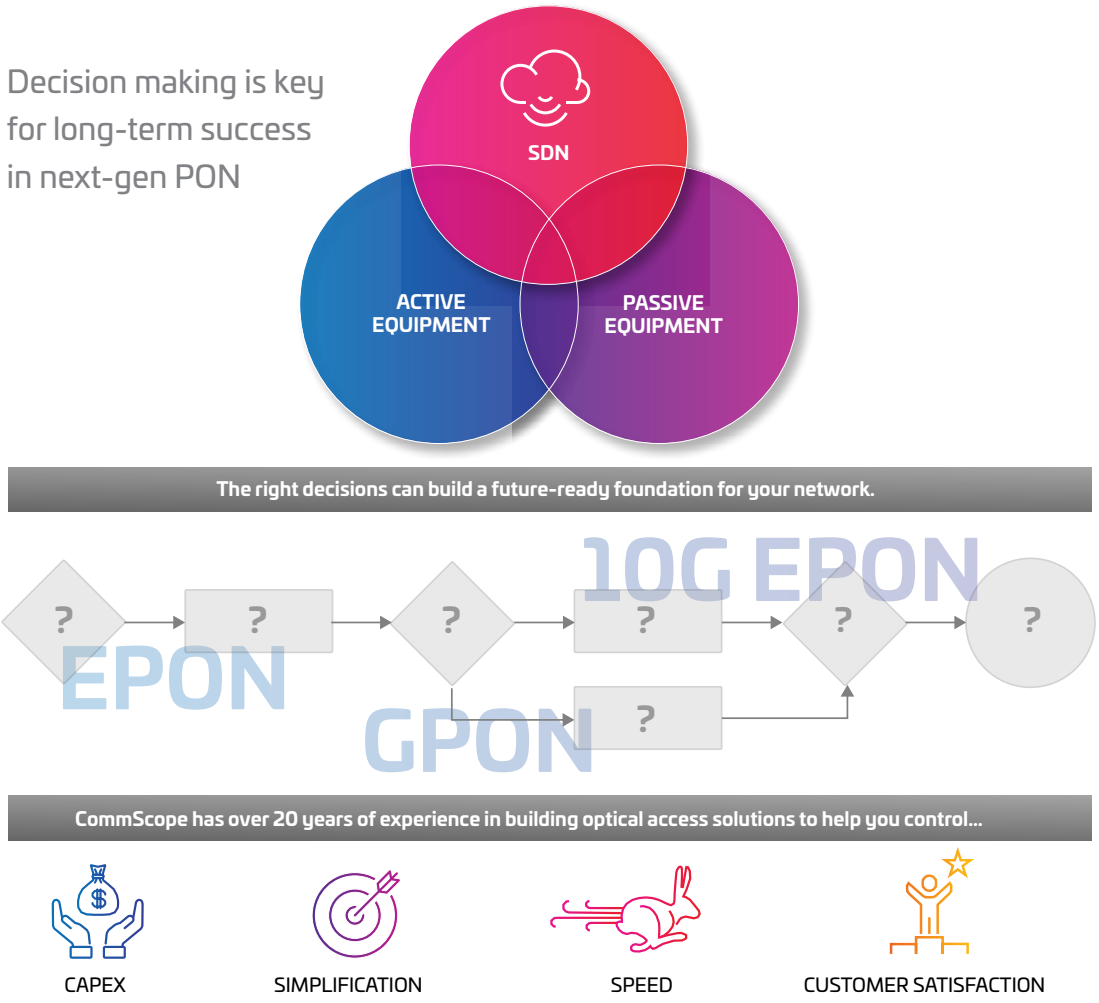
To be successful in next-generation PON, service providers need to consider their technology options carefully. The right decisions on active, passive, and software solutions can build a future-ready foundation that can create new opportunities to ensure long-term success.

Chief among these are the abilities to reduce infrastructure costs, to simplify and speed the addition of new subscribers, and to accelerate the delivery of new features. In planning for these outcomes, experience can make a world of difference.

After building optical access solutions for more than 20 years, CommScope understands what it takes to architect PON networks that have stood the test of time. We have deployed thousands of OLTs and millions of ONTs and have gained significant experience in the deployment of GPON, EPON, and 10G EPON. We operate one of the largest PON development, testing, and interoperability labs in the networking industry, and have become a leading advocate for open, standards-based PON solutions.

CommScope first deployed a disaggregated access network in 2002, and in 2016 we predicted that the road to disaggregation also required a distributed approach that moves the control and management software out of the network device and into the cloud. This approach is now commonly referred to as software-defined networking (SDN), which we believe is the single most important architectural principal for service providers to consider when choosing a PON platform. But there are many more.

The lessons and considerations in this eBook reflect CommScope's long heritage as an innovator in PON solutions, a leader within the key forums that are driving FTTH technology, and one of the industry's earliest architects of disaggregated, software-defined networks. Here are what CommScope believes are the most important areas to consider as you prepare for next-generation PON deployment.



Chapter 1

Prioritizing CapEx efficiency with a holistic approach

As with any network upgrade, the ability for service providers to control CapEx is critical in ensuring their investment provides a solid path to profitability. One way to reduce CapEx is to focus on hardware cost reduction. CommScope has learned that customers are able to significantly improve their return on hardware investments by maximizing their use of existing infrastructure. The key is to utilize as many existing facilities as possible and to choose hardware that is built for investment protection.

Reuse existing points of presence

Launching a PON network often requires that active OLTs are located where power, cooling, and environmental protection are assured. But, for many service providers—particularly those who have traditionally delivered DSL over twisted pair—cabinets, enclosures, and other points of presence aren't always where they need to be to support the density and distance requirements of today's PON architectures.

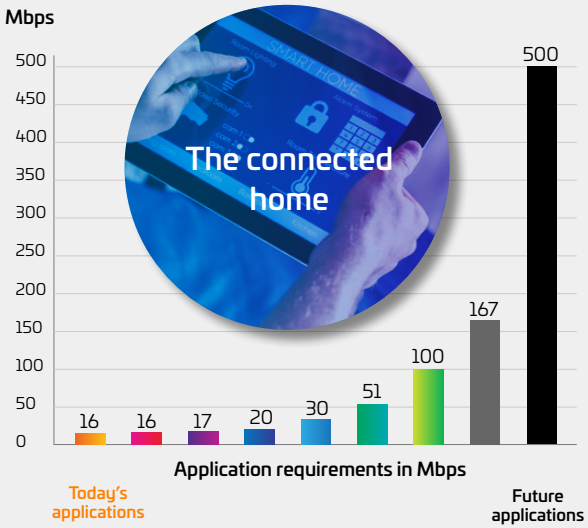
Because it can be extremely expensive to build new facilities to host actives, service providers should seek out OLT hardware that can be deployed in a variety of locations, including the central office, remote cabinets, and MDU environments.

Leverage existing fiber runs

One of the keys to launching PON is the availability of fiber where it is needed. But the high cost of fiber deployment, particularly for fiber runs between central facilities and remote locations, can be prohibitive. Unlike the fiber runs from the drop to the customer premises, spans between the central office and remote OLTs may cover long distances and need to be constructed well ahead of subscriber revenues. Such fiber runs also require rights of way, which can be time consuming and expensive to procure. This is a critical area for cost control.

The good news is that service providers often have existing fiber in these locations that can be leveraged for PON networks—even if it is

Applications continue to develop and consume more bandwidth—the case for FTTH with 10G access



Source: Cisco Annual Internet Report, 2018-2023

being used for other services. To maximize its use, choose PON solutions that support large-capacity network-side interfaces such as DWDM or 100G long-reach optics. Maximizing the capacity on existing fiber between the central facility and remote OLT will help avoid the need to run new fiber over long spans, thus significantly reducing the time and capital costs of PON deployment.

Lower the costs of PON hardware

For years, managing networking systems has relied on specialized hardware running on each device, which handles service provisioning, software updates, monitoring, and other important functions. But running the management software on the OLT device is inefficient and costly. That is because the specialized processing hardware it requires is expensive and needs to be replicated for each OLT in the network.

To reduce these hardware costs, consider running the management functions for OLT devices on COTS servers instead. These standard servers have achieved a level of commoditization that makes them the most cost-effective hardware choice for running PON management software. The cost advantage grows as the system scales, since COTS servers are designed for virtualization and can be shared among a variety of applications—and they are designed to be power efficient. But there are even greater cost advantages associated with this server-based approach.

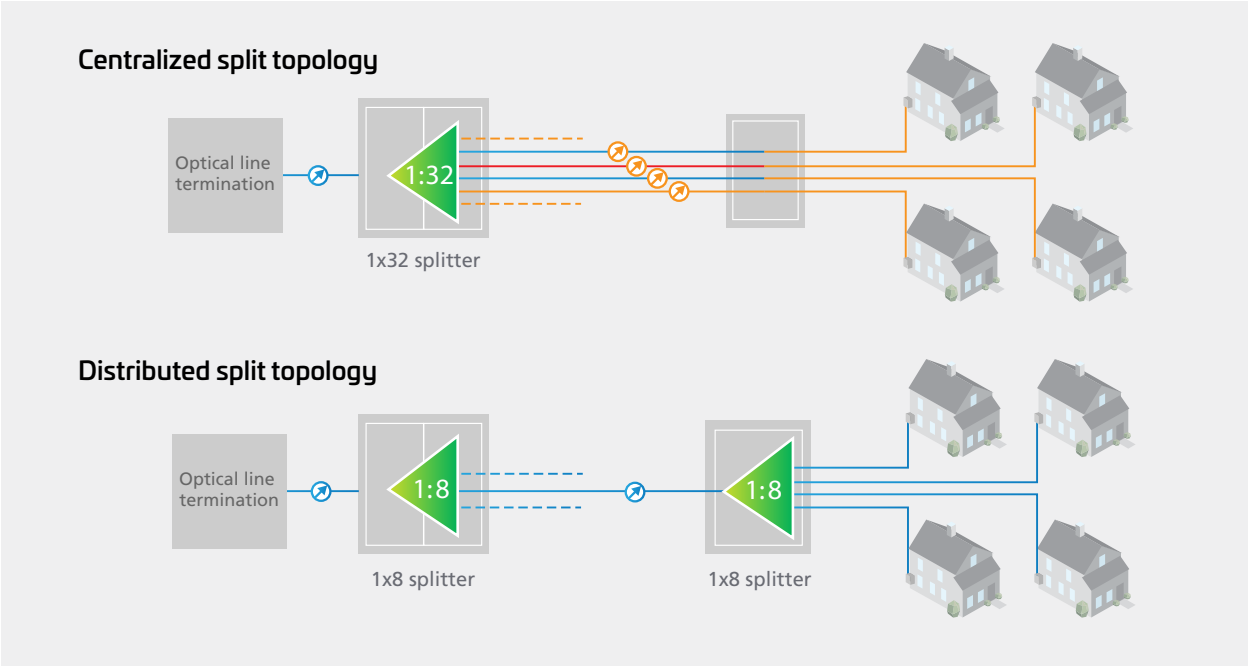
By disaggregating management software from the network hardware, it can be containerized and deployed on virtual machines within a range of popular cloud platforms. By moving network management to the cloud, service providers can reduce their fixed capital expenses and transition to an OpEx cost model where compute resources are spun up and torn down as needed for maximum cost savings.

Reduce the need for specialized networking hardware

Performing all network processing within a PON device can be costly and inefficient. While some networking functions, such as creating a hardened, non-blocking architecture, are well suited to OLT hardware, efficiencies can be achieved by decoupling layer 2 routing and switching from the network device. By combining a domain controller built on open standards with best-in-class routing and switching solutions, service providers can create a software-defined network throughout the PON.

This provides multiple benefits. The first is that hardware costs decline since the processing requirements are reduced for each OLT. In addition, maintaining an SDN within the PON provides a framework that lowers operational costs and improves service velocity, which is detailed later in this eBook. The use of open standards and software-defined networking also allows the service provider to choose the right network hardware for a given application, service, use case, or budget.

Two main network topology options



Choose the right network topology for fiber passives

When it comes to PON topologies using fiber cables and connectivity, there is no "one size fits all" approach that works well for every service provider and application. That is because today's networks have evolved in different ways and on different schedules, and service providers may place different priorities on costs, time to market, and other factors. By understanding the options upfront and choosing the right topology, service providers can maximize their use of existing cabling while either reducing their passive infrastructure costs or streamlining network deployment.

For networks that have abundant fiber between the splitter location and customer premises, a centralized splitting architecture can leverage existing fiber while enabling management and testing to be administered centrally within the hub. Service providers that have less fiber in the distribution area may instead choose a cascaded architecture to reduce the costs of cables, splice closures, and splicing labor. Other topologies, such as daisy-chain and star architectures, can speed

up deployments by using cabling more efficiently or reducing the requirement for splicing labor, respectively. And in rural networks, optical fiber tapping can be used to cover long distances efficiently where housing density is low.

In today's environment of escalating labor shortages, consideration should be given to assess the value of using some of the newer technologies that can simplify fiber network deployment. Advanced technologies such as fiber indexing, pre-connectorized cabling, and modular splice enclosures can also be effective in making the deployment of passives fast and cost effective in a variety of topologies.

Avoid vendor lock-in

While tightly integrated, proprietary hardware and software solutions have their advantages, they can also put service providers at a disadvantage in different ways. Long term, these single-vendor solutions can drive capital costs higher, slow down the rollout of new technologies and features, and create supply chain issues. That is why service providers are wise to continue to ask PON solutions providers for standards-based, open, and interoperable infrastructure.

Open PON solutions not only avoid locking service providers into OLT/ONU hardware, but management systems as well. A multivendor approach ensures continuous competition, which encourages vendors to keep device costs low, product availability high, and new capabilities flowing.

Key considerations for CapEx efficiency

Reuse existing points of presence	Seek out OLT hardware that can be deployed in a variety of facilities and locations
Leverage existing fiber runs	Choose PON solutions that support large-capacity network-side interfaces such as DWDM or 100G long-reach optics
Lower the costs of PON hardware	Consider running the management functions for OLT devices on COTS servers instead.
Reduce the need for specialized networking hardware	Efficiencies can be achieved by decoupling layer 2 routing and switching from the network device
Choose the right network topology for fiber passives	Assess your environment to reveal your options. Choose between centralized or cascaded, daisy-chain or star architectures or even optical fiber tapping for long rural runs
Avoid vendor lock-in	Ask PON solutions providers for standards-based, open, and interoperable infrastructure

Beyond CapEx efficiency

For service providers, the journey to next-generation PON deployment offers exciting new opportunities to prepare their networks for tomorrow, and these opportunities go well beyond well-informed hardware investments. In addition to being efficient with CapEx, today's service providers have a unique ability to architect PON in a way that simplifies network evolution, streamlines subscriber and service growth, and proactively reduces downtime. These factors can help service providers ensure that their PON strategies are future-ready and well aligned with their operational goals.

Chapter 2

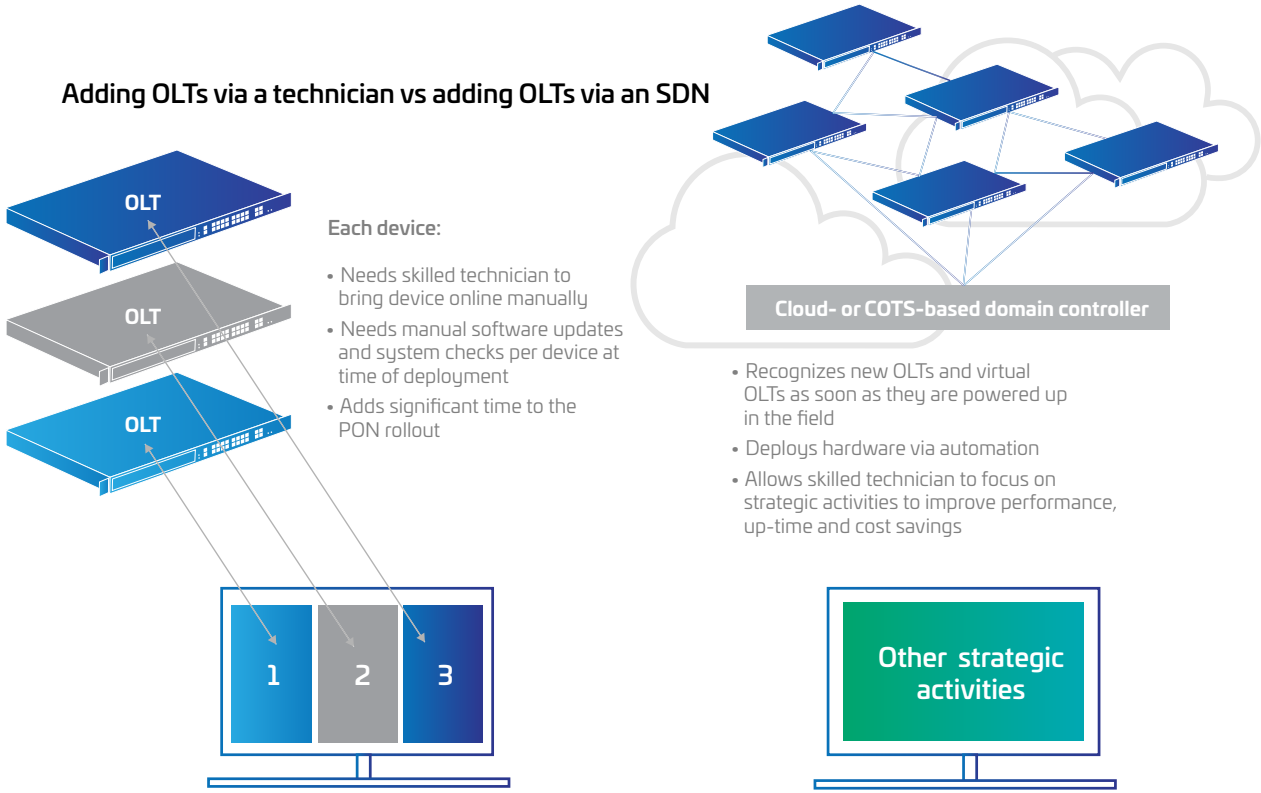
Designing for operational simplicity, scalability, and savings

Service providers that are planning to deploy PON are in a unique position to architect their networks for years of service and subscriber growth. Among the most important considerations in this planning stage are the simplification of routine network functions, the ease with which the network can be scaled, the improvements in uptime, and the increases in service velocity that result when the right architectural decisions are made on day one. Not only can sound planning decisions help ensure that PON networks are future-ready, but they can also significantly lower management and operating costs. In this chapter, we will explore the key considerations that can help service providers plan their PON deployments with operational simplicity, savings, and scalability in mind.

Streamline OLT onboarding

Whether deployed in the central office or remotely, OLTs can be time-consuming to administer throughout their lifecycle. That is particularly true in the onboarding stage, when a technician must bring each new device online. When the OLT's control plane software resides on the device itself, this means a technician performs initial software updates, system checks, and other start-up tasks at the point of deployment. This can add significant time to PON rollouts and increase the demand for specialized technical staff.

To make PON systems faster and easier to onboard, a software-defined network (SDN) architecture built on modern microservices provides a key advantage. In an SDN environment, the cloud- or COTS-based domain controller recognizes new OLTs and virtual OLTs as soon as they are powered up in the field. It



then uses automation to bring these devices online quickly and without the need for highly skilled network engineers. This hands-free onboarding makes OLT deployment a routine task and reduces the operational impact of PON rollouts.

Scale PON networks quickly and easily

Onboarding is not the only stage of the OLT lifecycle where ease of administration is important. That is because PON-based broadband services are projected to grow quickly, and, as the network grows, so does the work required to expand capacity and increase the number of homes passed. In a network environment where growth is a given, **it is important to be able to add ports to the network quickly and easily.**

The ability to do this stems from the network's disaggregated control and management planes, which allow service providers to scale from very small deployments to very large deployments—very quickly. An OLT can be installed with as few as two ports, then additional ports can be added as needed, with the required control plane resources such as compute and memory located in the cloud, where they are easy and cost-effective to scale.

As PON systems grow, it is also important that the hardware supporting the domain controller in the network operations center or cloud can be scaled easily. That presents another opportunity for a software-defined networking solution. By running the domain controller on COTS- or cloud-based servers, operations personnel can scale the system simply by provisioning compute resources, configuring a virtual machine, and installing the software.

Simplify PON maintenance

Managing PON hardware through a traditional command line interface can be cumbersome and often requires specialized, time-intensive training. This can make it difficult to find qualified operational staff members, while burdening valuable employees with routine network management tasks. That is where a modern, SDN management application and automation based on industry standard interfaces can simplify and streamline PON maintenance.

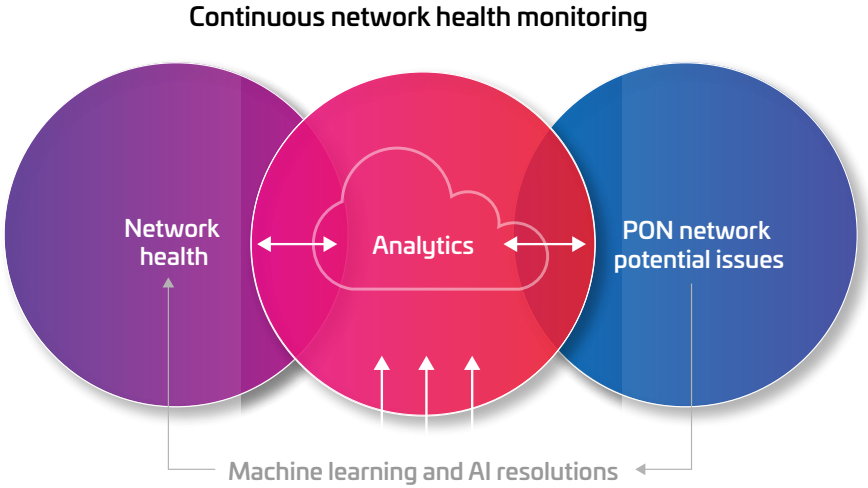
Open, standards-based interfaces provide a mechanism for the domain controller to connect with the northbound orchestration layer. That enables service providers to create and customize powerful GUI-based management applications with closed loop automation capabilities. These intelligent management systems make it easy for staff to perform basic PON maintenance tasks, such as software upgrades, configuration back-ups, and resiliency testing.

Since they are easy to learn and operate, these intelligent network management systems also expedite employee training, help create power users more quickly, and reduce the ramp-up time for new hires. Because they align with today's common data center management tools and techniques, these server-based applications help broaden the pool of talent available to work in the field of PON network management. Most importantly, intelligent management systems free up highly skilled network engineers to perform high-value activities such as network trend and load analysis, network capacity planning, subscriber application usage monitoring, and trend analysis.

Reduce ongoing power and management costs

OLTs require significant power, with electricity costs that can grow quickly as PON achieves widespread deployment. That makes it advantageous to extract management and control plane functions from remote devices and run them within modern data center architectures instead. This helps reduce operating costs in multiple ways.

First, utilizing shared compute resources is more power efficient than distributing them across the network within OLT devices, so immediate cost savings occur when these functions are moved onto standard servers. Once they are server-based, their compute resources can also be shared by other applications to increase hardware utilization and make management more efficient. Also, the reduced computing requirements for OLTs means these devices can now be cooled with passive heat dissipation rather than active fans—driving power costs even lower while simplifying maintenance and expanding deployment options. When compared to software that is integrated into the OLT, the operational savings of server-based resources can be substantial.



Enable predictive, proactive service assurance

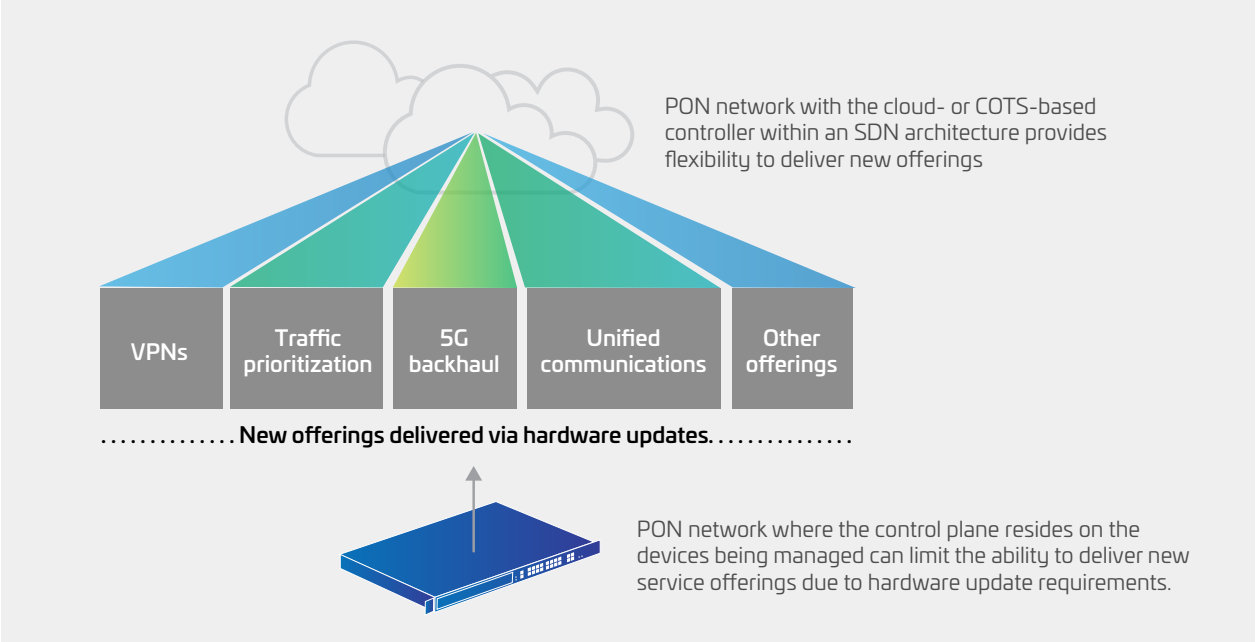
Managing a modern access network goes beyond service provisioning and reactive troubleshooting. To keep uptime and customer satisfaction at their highest levels, it is best to stay ahead of issues and employ a proactive approach, which prevents small issues from turning into big problems. That is where **a service assurance platform built on machine learning and AI can really help.**

By collecting key information about the health of the network, centralizing it, and presenting it to the organizations and applications that rely on it, the service assurance platform can give PON network operators visibility into potential issues in real time. In many cases, machine learning and AI can then be employed to resolve them automatically—before they impact performance or create downtime.

Accelerate service velocity and maintain a competitive edge

Once PON networks are commonplace amongst network operators, service providers may take a break from competing with one another on data rates alone. But that does not mean they will stop competing. The new competitive battlefront will likely be on advanced services such as VPNs, traffic prioritization, 5G backhaul, unified communications, and a range of innovative offerings that go well beyond bandwidth. But today's method of bundling new features with infrequent network hardware updates has the potential to stifle the rollout of advanced features and provide an advantage to competitors that can innovate faster.

To win the feature race, service providers can seek out PON systems that are built on a modern software-defined architecture. By decoupling new features from the control plane and running them as microservices within a cloud-based domain manager instead, software teams can create new capabilities using today's agile processes and tools, test them thoroughly, deploy them widely, license them independently, and release them frequently. Because new features can be activated without waiting for the next hardware update—and deactivated just as easily—the pace of innovation within a modern PON network can be substantially faster than it is within legacy systems.



Critical considerations for next-gen PON

So far in this eBook, we have explored the top considerations for service providers that are planning next-generation PON deployments, focusing on the capital and operational decisions that can help create a foundation for future-ready network architectures. Many of these considerations favor an open, disaggregated, software-defined PON network as the key to unlocking the benefits of hardware savings, operational efficiency, and long-term subscriber and service growth. In the next and final chapter, we will examine the real-world factors of deployment time and costs for a next-gen PON network in an example rural environment.

Chapter 3

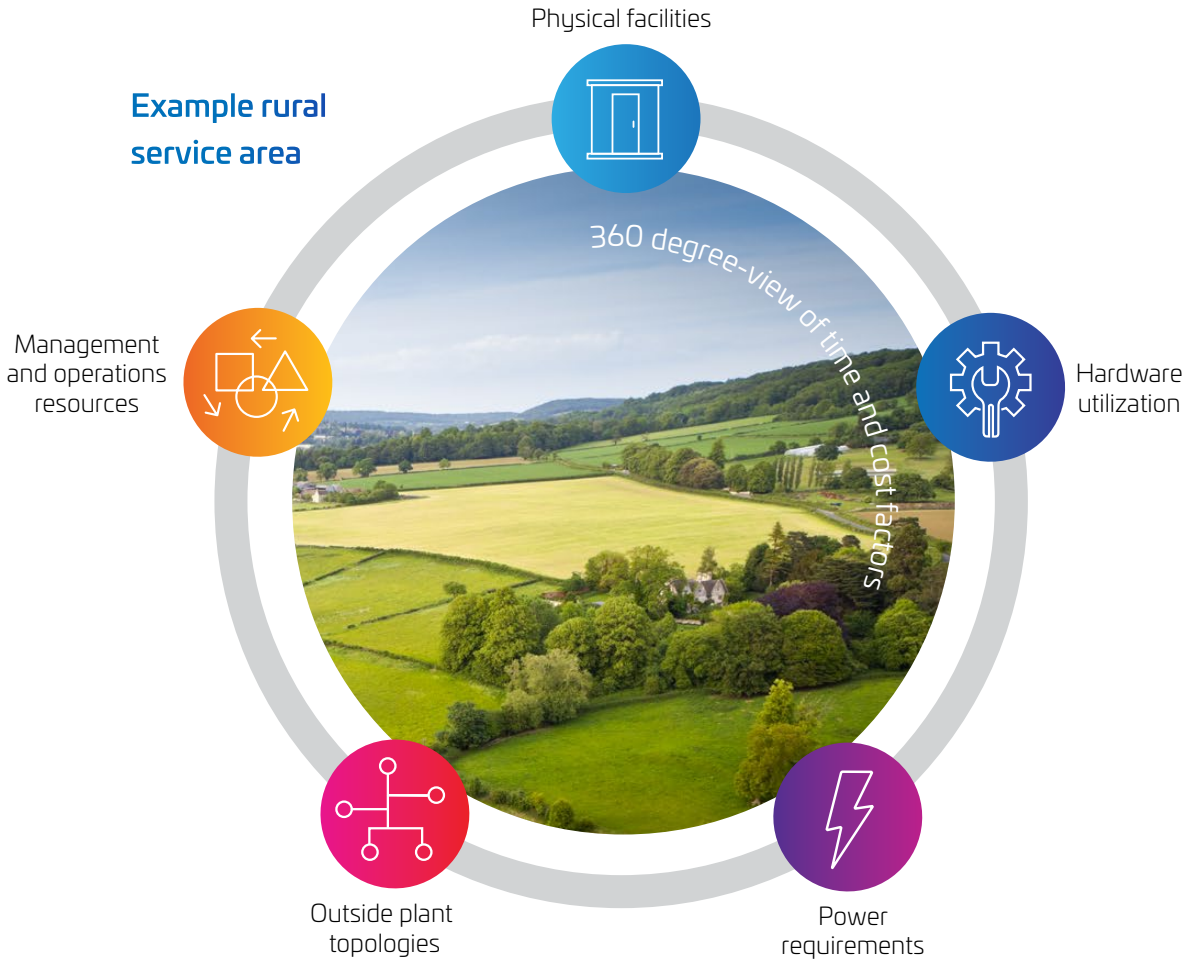
A 360-degree view of deployment time and costs for a rural PON network

For years, rolling out advanced broadband services in rural markets has been challenging due to the unique dynamics of these environments. It has been difficult for service providers to justify the time and financial investments it takes to construct next-gen networks in areas where subscriber density is low and revenue opportunity can be less than it is in urban and suburban markets. But new public funding programs are about to level the playing field and create a substantial opportunity for service providers to build next-gen PON networks in rural markets around the world.

Even though funding is available, service providers must consider their PON deployment costs carefully. In many cases, funds are awarded based on the service provider's ability to demonstrate the financial viability of their plan. In addition, speed of deployment is a chief concern. Public funding often comes with strings attached in the form of a set of milestones that must be achieved throughout the project lifespan. To further complicate matters, many of today's PON solutions have been optimized for the deployment dynamics and economics of high-density environments.

For these reasons in particular, it is critical for service providers to develop a 360-degree view of the time and cost factors of rural next-gen PON deployment. Several dynamics, including physical facilities, hardware utilization, power requirements, outside plant topologies, and management and operations resources, can have a substantial impact on PON deployment time and costs.

In this chapter, we'll model data from a deployment area with an average of 7.6 homes per mile (4.7 homes per kilometer) as we explore the factors that are critical to the successful rollout of PON in rural markets.



Reducing physical facilities costs and deployment time

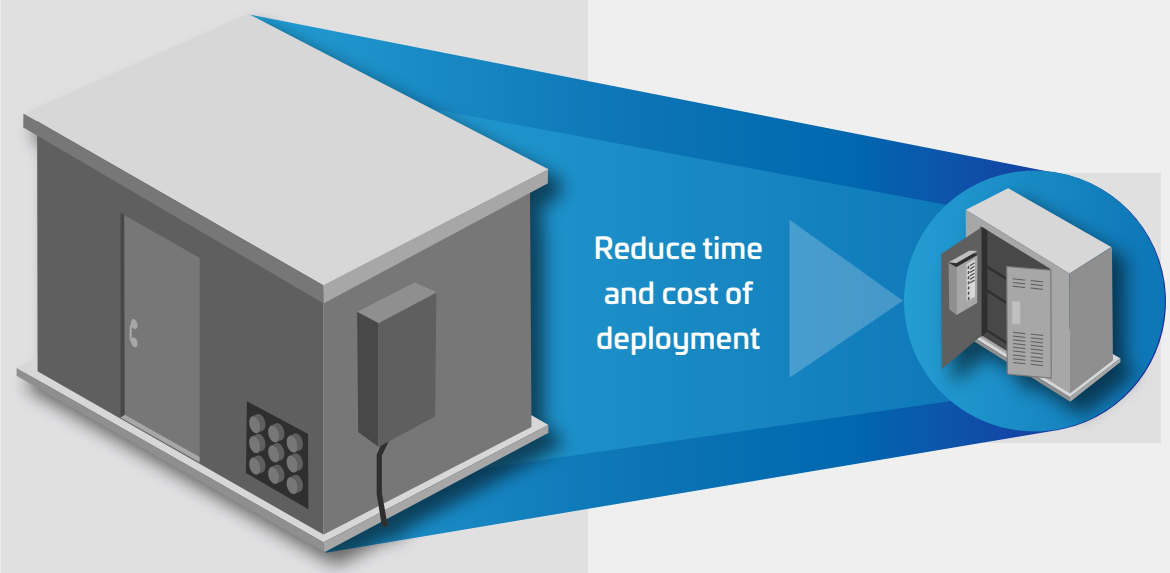
One of the primary challenges of PON deployment in rural environments is posed by the distance that often separates the service provider's existing hub or central office facilities from end user locations. And in the case of greenfield deployments, service providers may not have these traditional facilities in place at all. In both cases, it is often impossible to serve every subscriber using centralized physical locations. In these cases, new facilities are needed—but the time and costs of constructing them can be prohibitive. In this traditional approach, permitting, site preparation, transportation, construction, point of presence (POP) and the procurement of equipment for a new walk-in facility or a mini hub can cost hundreds of thousands of dollars per site and take several months to complete from start to finish.

In the case of our example rural PON serving area, it was determined that seven new facilities would be needed to reach every home, requiring significant time and substantial costs to construct. As each of these POPs would only serve a few hundred homes at best, this would drive up the cost per home to levels well above the industry average for denser areas. However, today, new options based on moving the OLT to the edge by using a remote OLT (R-OLT), are available at a fraction of the cost and time needed to deploy traditional facilities.

Replacing traditional facilities with R-OLTs reduces time and cost of deployment

We found that both cost and time could be reduced significantly when the construction of walk-in facilities was replaced with the use of environmentally hardened R-OLT shelf devices placed within outdoor cabinets. By doing so, we found that infrastructure cost savings could range range from 40 to 80 percent depending on the situation and whether an existing cabinet and power are already available. We also found that deployment time can be reduced by 70 to 80 percent when compared to traditional facilities.

Replacing traditional facilities with R-OLTs reduces time and cost of deployment



Increasing hardware utilization

Because many of today's existing OLTs have been designed to meet the needs of high-density urban and suburban markets, it can be difficult to keep hardware utilization high in rural PON networks. A more CapEx-efficient way to deploy PON is to use OLTs that can be deployed initially with low port counts and high split ratios (1:128) and scaled by adding ports and moving to a lower split ratio (1:64) as capacity is needed. In this case, using cabinet-based remote OLTs enabled the cost-effective deployment of infrastructure for very small serving areas and a seamless migration path toward future growth—all while keeping hardware utilization optimized for both cost and capacity.

Improving management and service efficiency

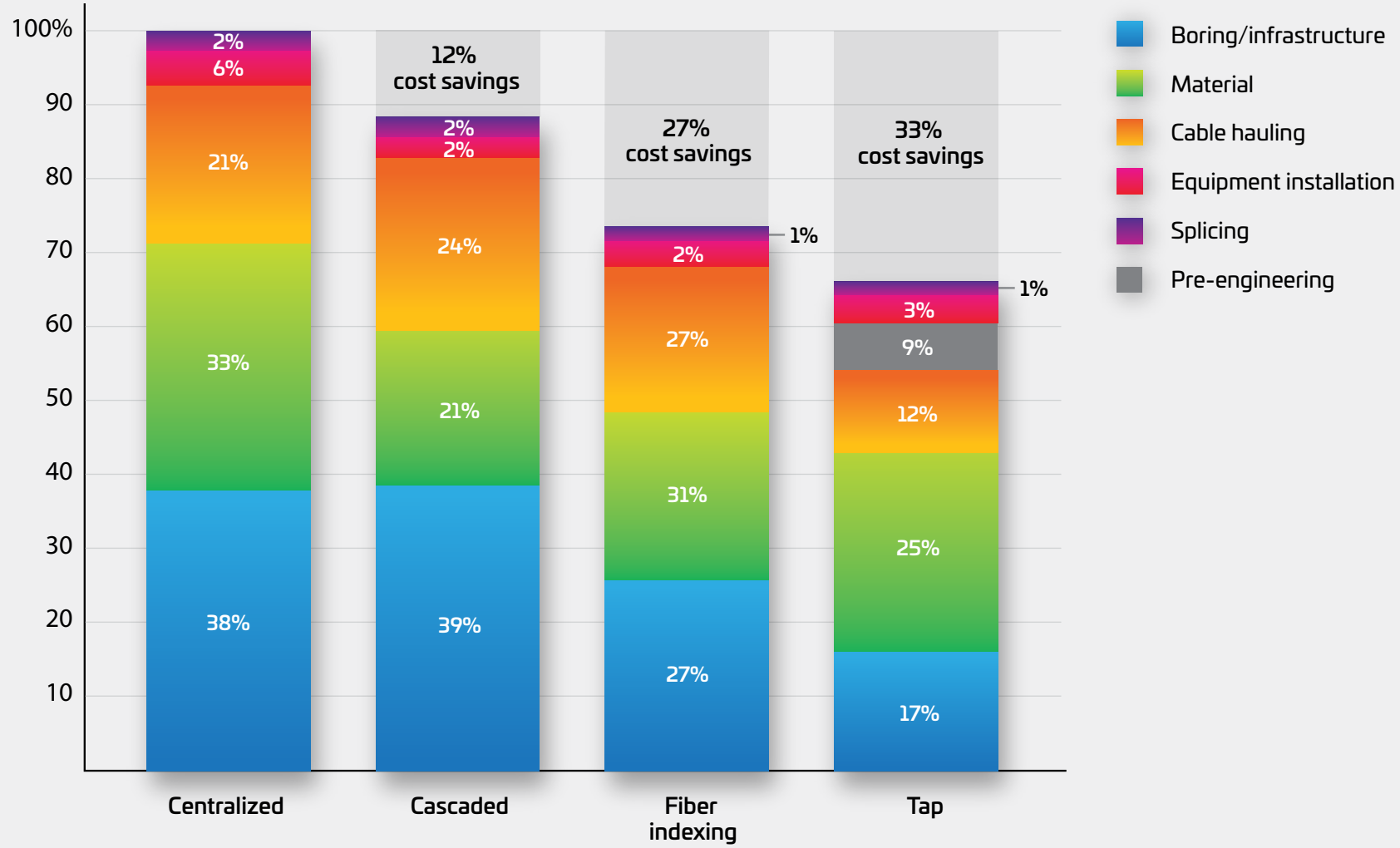
An additional dynamic we examined in this rural PON deployment was the management and service overhead required to keep this network up, running, and growing. By deploying R-OLT and shelf OLT devices that leverage modern software rather than legacy OLTs in traditional facilities, the volume and complexity of annual truck rolls per site was shown to be reduced significantly. This is made possible by a range of advanced software capabilities that enable the R-OLT to be provisioned with zero touch and managed remotely with automation.

Optimizing outside plant investments

In the rural environment we studied, we found multiple opportunities to reduce the costs of fiber deployment through the careful selection of fiber topologies and technologies. The first area of savings stemmed from the inherent fiber efficiency of remote OLTs, which reduce the fiber count requirements in the feeder network and place the last active device much closer to subscribers than is possible with centralized facilities. In addition to being cost effective, placing remote OLTs deep in the network improves optical budgets between the OLT and home, enables more choice in split ratios, helps extend service over long distances, and allows for the use of more connectorized solutions which can facilitate and speed up the process of connecting new subscribers.

The second savings opportunity arose through the usage of cascaded, tap, and indexing technologies. While they can add incremental passive connectivity costs to PON deployments, they can significantly reduce the labor requirements and deployment time of running new fiber when compared to centralized architectures. This is due to the plug-and-play nature of connectors and their ability to reduce splicing, cable hauling, pre-engineering and other tasks.

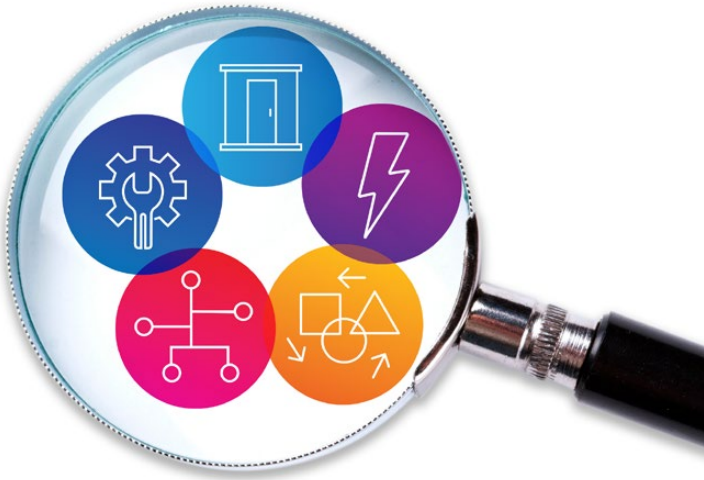
Comparative cost analysis of topologies



Conclusion

As service providers begin planning, architecting, and deploying next-gen PON networks, there is a lot to think about. There are often tradeoffs between near-term capital investments and long-term operational costs, and the two must be balanced in accordance with the service provider's unique business priorities. There are decisions to be made about how to evolve from existing technologies to what is next. There is a learning curve with next-gen technologies that need to be considered in light of the advantages of going modern. And then, of course, there's speed. Service providers are wise to consider how quickly they can get their next-gen PON networks up and running and choose technologies that help them roll out new features and capabilities quickly and efficiently.

In this eBook, we've brought forth some of the most important considerations in next-gen PON planning through the lenses of cost and time to market. Through the exploration of these key factors and the examination of a real-world rural network deployment, we have concluded that many of the top objectives service providers have can be met with modern, next-gen PON systems that are software defined with OLT options that can be deployed remotely. We have also demonstrated the value of advanced management platforms and fiber technologies, which can help optimize both the cost and speed of PON deployment.



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