

Passive optical LAN explained

Understanding the technology for a more advanced enterprise network

Strategic White Paper

Network architects have used local area network (LAN) switches to manage the volume of traffic in enterprise networks for more than 30 years, but over this time there has only been a few substantial changes to the basic design of traditional, copper-based Ethernet networks. However, the performance and physical characteristics of copper-based Ethernet LAN cabling impose a number of limitations on an enterprise LAN. Passive optical LAN (POL) technology eliminates the networking limitations and addresses the evolving demands of enterprises with fiber optic cabling that delivers all services on one efficient, high-capacity network. This paper outlines the key elements of an enterprise POL and explains why it is the best enterprise network option for tomorrow's digital enterprise.

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Introduction

Successive generations of copper-based Ethernet technology have been the foundation of enterprise networks for more than 30 years. During that time, enhancements such as faster speeds, less noise and more efficient signaling have been applied to meet the increasing information management requirements of the ever-changing enterprise. Yet, the twisted pair copper-based wiring at the heart of Ethernet networks has limitations.

Passive optical LAN (POL) technology eliminates the networking limitations imposed by traditional copper-based Ethernet. It addresses the evolving demands of enterprises with fiber optic cabling that delivers all services on one efficient, high-capacity network. Deployed as a replacement for copper or as a new installation, it can enhance the service experience, improve mobile connectivity, reduce costs and deliver value for decades.

This paper outlines the key elements of an enterprise POL and explains why it is the best enterprise network option for tomorrow's digital enterprise.

Understanding POL networks

For the past three decades copper-based Ethernet enterprise networks have been designed to deliver services to end users through access points at the edge of the network. Over this period network architects have used LAN switches to manage the volume of traffic from the access points and through the network. As Gartner notes, there have been few substantial changes to this basic design. Equipment vendors have continued to pursue this approach to “justify high average selling prices (ASPs) and continue fueling the enterprise LAN switching market.”¹

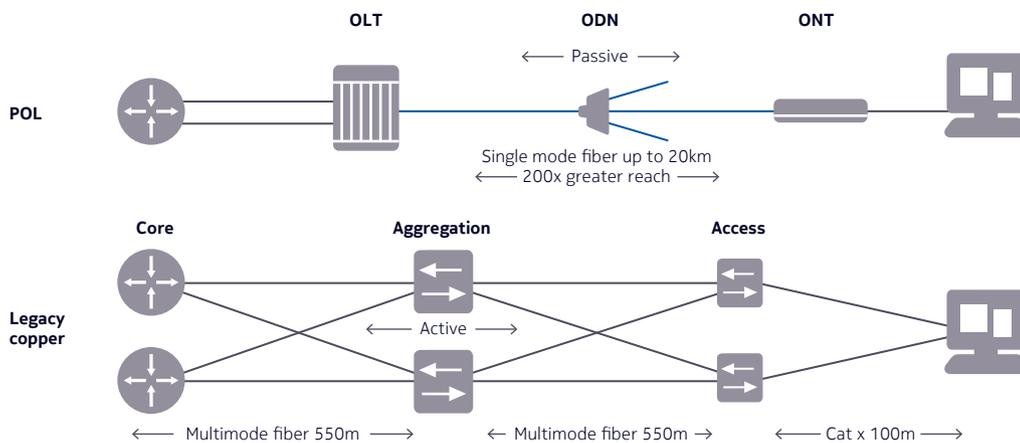
Unfortunately, the performance and physical characteristics of copper-based Ethernet LAN cabling impose a number of limitations on an enterprise LAN. The most obvious one is the way in which traditional enterprise networks are designed.

¹ Gartner, 2011. “Rethinking LAN Switching Architectures,” February.

Architecture

To deliver high-performance service to all users at all times, traditional enterprise infrastructures are built on a distributed architecture with core, distribution, aggregation, access layers and active elements distributed throughout a building (see Figure 1). In these LANs, the limitations of the copper cabling determine the location of the server and the core and access layer switches, as well as the equipment rooms in which they reside.

Figure 1. Traditional LAN network design with multiple layers and distributed elements²



Typically, the length of a copper cable link between two active devices in an enterprise installation is restricted to a maximum of 100m for Cat 5 and Cat 6.³ This allows for 90m of solid core permanent wiring, two connectors and two stranded 5m patch cables at each end. Exceeding the maximum cable/patch cabling length will cause signal loss. For speeds exceeding 1Gb/s and up to 10Gb/s, the solid core permanent wiring distances must be reduced to 50m or less, depending on noise and interference. The installers will have to add active hardware such as repeaters or switches for longer runs. Consequently, large buildings or sprawling campuses will require more distributed elements, equipment rooms and cabling; it then becomes a costlier deployment.

A POL offers enterprises a better networking option compared to copper because it is built on fiber optic cabling, which gives POL networks a significantly higher reach compared to copper cabling (20km to 40km compared to less than 100m for higher speeds). This allows for a flatter, centralized LAN design where the key element placements are not limited

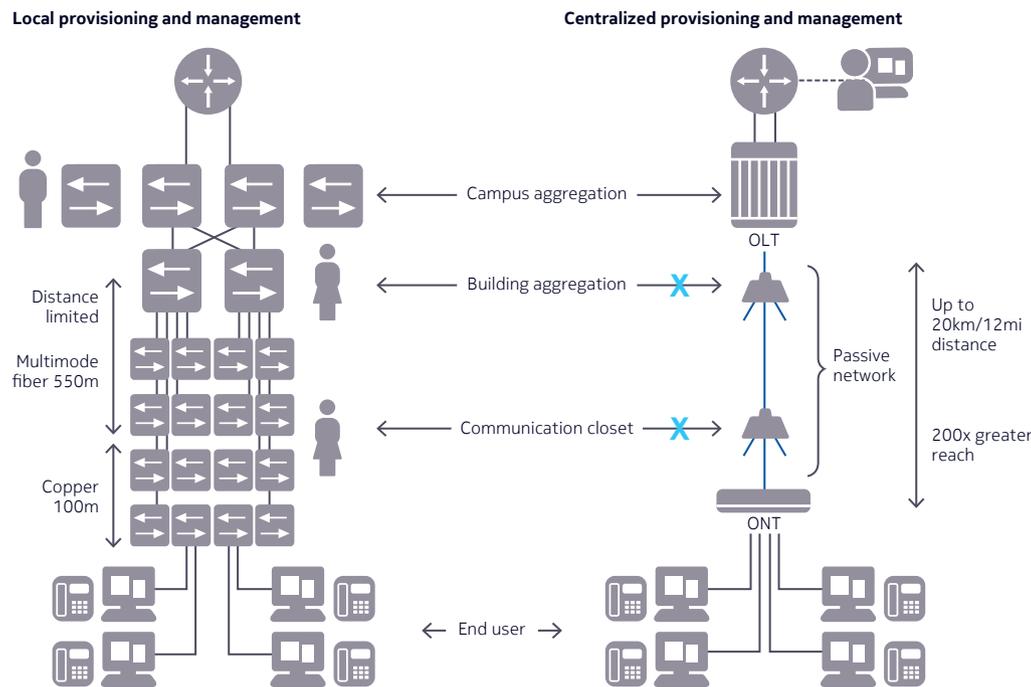
² The Association for Passive Optical LAN. "Passive Optical LAN Overview and Benefits" (<http://www.apolanglobal.org/resources/>).

³ Le Van-Etter, Loni, 2013. "Design and Installation Challenges and Solutions for Passive Optical LANs," 3M Communication Markets Division.

by the distance and bandwidth constraints of twisted pair copper wiring.⁴ It enables deployment of basic network elements at a central location and provides flexibility in terms of routing the fiber cabling to connect multiple buildings inside large enterprises or campuses. Recent advances in fiber cabling, such as bend-insensitive single mode fiber, enable an enterprise network architect to choose from multiple cable designs and to also achieve faster deployment speeds. Fiber is also less susceptible to noise and interference, providing even more flexibility in routing.

A centralized POL infrastructure has a smaller equipment footprint compared to an Ethernet LAN. It requires fewer racks, LAN switches and patch panels (see Figure 2). This eliminates the need for telecom equipment closets on each floor or at every 100m, extra power supplies and a uninterruptible power supply (UPS) associated with equipment rooms, as well as additional air conditioning, special cable channels for Cat 5/Cat 6 cabling and other support requirements. As a result, enterprises benefit from significant savings on initial capital expenditures (CAPEX), as well as reductions in daily operating expenditures (OPEX) due to lower energy consumption and less maintenance.

Figure 2. Traditional LAN architecture versus POL architecture⁵



4 The Association for Passive Optical LAN. "Passive Optical LAN Overview and Benefits" (<http://www.apolanglobal.org/resources/>).

5 Ibid.

Technology

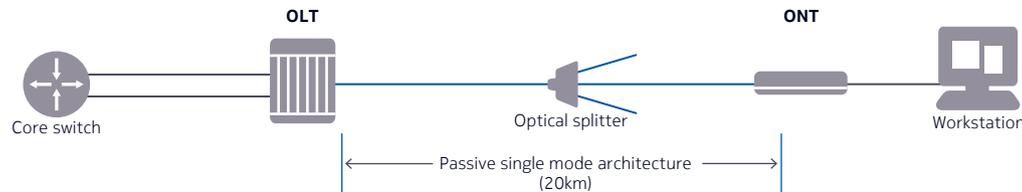
The centralized architecture in an enterprise network built on POL is enabled by Gigabit Passive Optical Network (GPON) technology that has been deployed successfully for residential, business and mobile backhaul applications. GPON is the fastest growing broadband access technology worldwide. It delivers voice, video and data services over an optical fiber.

Unlike copper, fiber cabling uses waveguides to transport information from one point to another in the form of light rather than electrical signals. The fiber itself is passive and does not contain any active signal generating properties.⁶ This simplifies network design, eliminates many of the deployment challenges associated with copper, and makes it easier to add or change network elements as needed.

As illustrated in Figure 3, a POL enabled by GPON consists of:

- Central access node – optical line terminal (OLT)
- Multiple user modems – optical network terminals (ONTs)
- Unpowered fiber and splitters that run between the OLT and ONTs.

Figure 3. Core elements of a POL⁷



The OLT is the central access node that aggregates the traffic from all connected users and devices. It has a variety of built-in capabilities, including user authentication and management, service prioritization, counters and statistics collection, troubleshooting and performance monitoring. The OLT has PON ports that support the connection of multiple optical fibers — a splitter separates the fibers. The ONT terminates the fiber, converts the optical signal into an electrical signal, and connects to user devices using Ethernet ports.

Much higher Ethernet port densities are possible in a POL, compared to a traditional Ethernet LAN. Assuming there are 16 PON ports on an individual OLT card with a typical enterprise split ratio of 1:32, one card can support 512 ONTs. A typical 5RU shelf can have four of these cards, so one shelf can typically support 2,048 ONTs. Different ONT configurations are available

6 Corning Cable Systems, 2006. "Understanding Fiber Optics and Local Area Networks."

7 The Association for Passive Optical LAN. "Passive Optical LAN Overview and Benefits" (<http://www.apolanglobal.org/resources/>).

that provide multiple Ethernet ports, analog voice ports, coaxial video ports and even wireless support. A typical configuration will have between four and eight ports that will support more than 8,000 connected devices.

Today, GPON provides a massive amount of bandwidth: 2.5Gb/s downstream and 1.2Gb/s upstream. This can be easily scaled to provide from 10Gb/s to 40Gb/s to every desktop in the future, without removing the underlying network infrastructure.

Converting to POL

A POL is the ideal alternative for enterprises considering an upgrade to their installed copper-based Ethernet network. Generally, upgrading a copper-based enterprise network requires a substantial investment in new switches and, perhaps, new cabling. The lifespan of the upgrade may not extend beyond five years from installation. On the other hand, a POL installation can be more cost effective and last for decades.

Technical advantages

Because optical fiber is more resilient and supports a smaller bend radius compared to other cabling, it can fit in existing ducts and channels easily. It is inherently resistant to signal and noise interference from other sources, so it can operate almost anywhere. After installation, existing legacy services such as analog voice or RF-based services (e.g. TV, surveillance and security) can be easily migrated to the new optical infrastructure to enable a single network for all services.

Beyond initial deployment, an investment in this technology clears the path to time and wavelength division multiplexing PON (TWDM-PON), the next evolutionary fiber access technology. This technology supports up to 40Gb/s symmetrical bandwidth and beyond (in the future) by multiplexing four or more optical wavelengths on the same fiber cable. TWDM can be deployed on top of GPON through an OLT enhancement; the two technologies can coexist on the same fiber. Therefore, enterprises investing in POL networks can evolve to TWDM using the same fiber, splitters and OLT. Furthermore, TWDM upgrades can be applied gradually. The technology allows enterprises to introduce one wavelength at a time based on service demand and only at those locations where the higher speed is needed. The remaining locations can continue undisturbed.

Finally, based on these advantages, a deployed POL can remain in operation for decades without any significant cabling upgrades, whereas a copper-based LAN must be upgraded with every new cabling standard.

Operating advantages

An enterprise network built on POL also offers a number of operating advantages. The coverage area for Ethernet LANs ranges from 30m–100m, depending on the cable type used and the bit rates offered. Businesses must add many switches/LAN rooms and patch panels to provide coverage in tall buildings or throughout extensive campuses. This means increasing investments in equipment, deployment, maintenance, power consumption and storage space. By contrast, a POL provides coverage for distances up to 20km. A single energy-efficient access node can serve a tall building or large campus. There is no need to add switches or patch panels to cover a new site because fiber cables can simply be extended to the new endpoints.

The OLT is the only active element that requires maintenance in a POL. The entire network can be easily managed from one point, using an integrated management platform or user-friendly Web interface.

Finally, a POL contributes to green operations because it requires 90 percent less floor space and consumes 40 percent less power compared to a copper-based Ethernet network. A single OLT can serve an entire building or campus and be stored in a single communications closet. Splitters can be located on floors or on walls. Modems or ONTs can be placed on desktops or walls. And floor space freed up by a passive optical LAN can be converted into additional meeting rooms, offices or desk space that would help generate revenue or increase efficiency.

Ultimately, the power and energy efficiency gained with a POL can enable enterprises to meet and exceed green certification initiatives, such as Leadership in Energy and Environmental Design (LEED) certification.⁸

Summary

A fast, reliable and cost-efficient LAN remains an essential enabler of successful enterprise operations. Passive optical LANs address evolving enterprise service demands with outstanding performance based on a flatter, centralized architecture that eliminates many of the challenges associated with traditional copper-based Ethernet networks.

Enterprises can get more value from a POL network that is engineered from the ground up and that will last for decades. They can leverage the benefits of proven GPON technology that offers unlimited bandwidth potential to deliver voice, video and data services at 2.5Gb/s upstream and 1.2Gb/s downstream today, and as high as 40Gb/s (and more) in the future on the same fiber infrastructure. Plus, they can process data more efficiently, reduce information management and communications costs and improve their bottom line.

⁸ US Green Building Council (<http://www.usgbc.org/leed>).



Most importantly, they can eliminate the costly LAN switch upgrade cycle and position themselves for a cost-effective network evolution that delivers the full benefits of new communications technologies for years to come.

Acronyms

ASP	average selling price
CAPEX	capital expenditures
GPON	Gigabit Passive Optical Network
LAN	local area network
LEED	Leadership in Energy and Environmental Design
ODN	optical distribution network
OLT	optical line terminal
ONT	optical network terminal
OPEX	operating expenditures
POL	passive optical LAN
RF	radio frequency
TWDM-PON	time and wavelength division multiplexing PON
UPS	uninterruptible power supply

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Product code: PR1602018026EN