Optical LAN explained

Understanding the technology for a more advanced and sustainable 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 LAN networks. However, the performance and physical characteristics of copper-based LAN cabling impose a number of limitations on an enterprise LAN. 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, energy-conscious and high-capacity network. This paper outlines the key elements of an enterprise Optical LAN and explains why it is the best enterprise network option for tomorrow's digital and sustainable enterprise.

Contents

Introduction

Successive generations of copper-based LAN 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 enterprise LAN networks has limitations.

Optical LAN technology eliminates the networking limitations imposed by traditional copper-based LAN. It addresses the evolving demands of enterprises with fiber optic cabling that delivers all services on one efficient, green and 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 while lowering the environmental footprint.

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

Understanding optical LAN networks

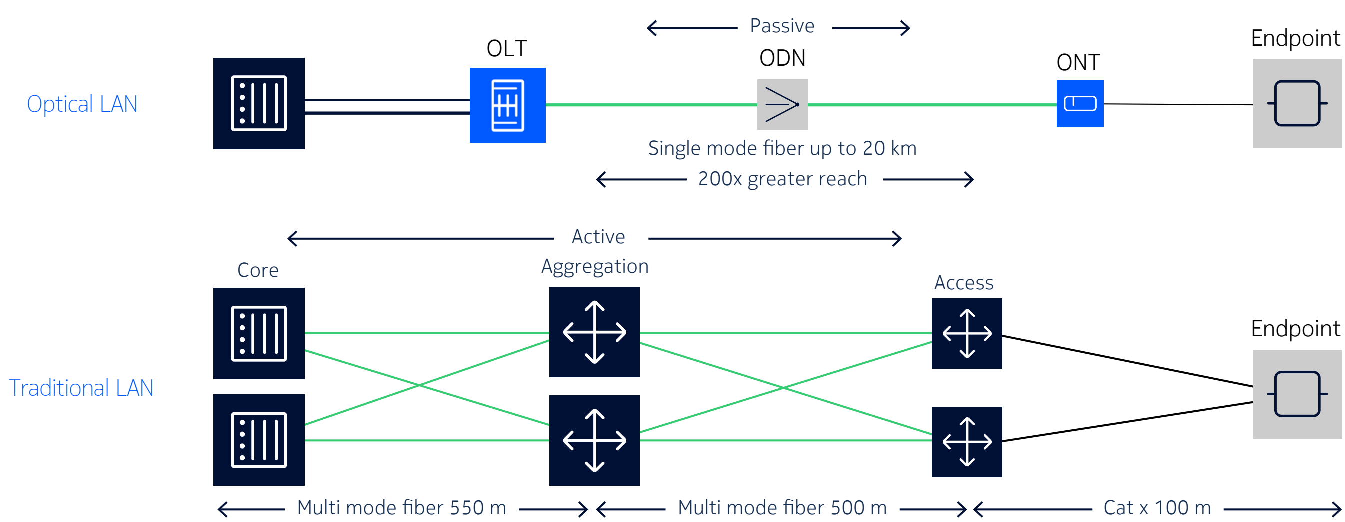
For the past three decades copper-based LAN enterprise networks have been designed to deliver services to end users through access points at the edge of the network. Over this period network architects have used LAN switches to manage the volume of traffic from the access points and through the network.

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

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 elements

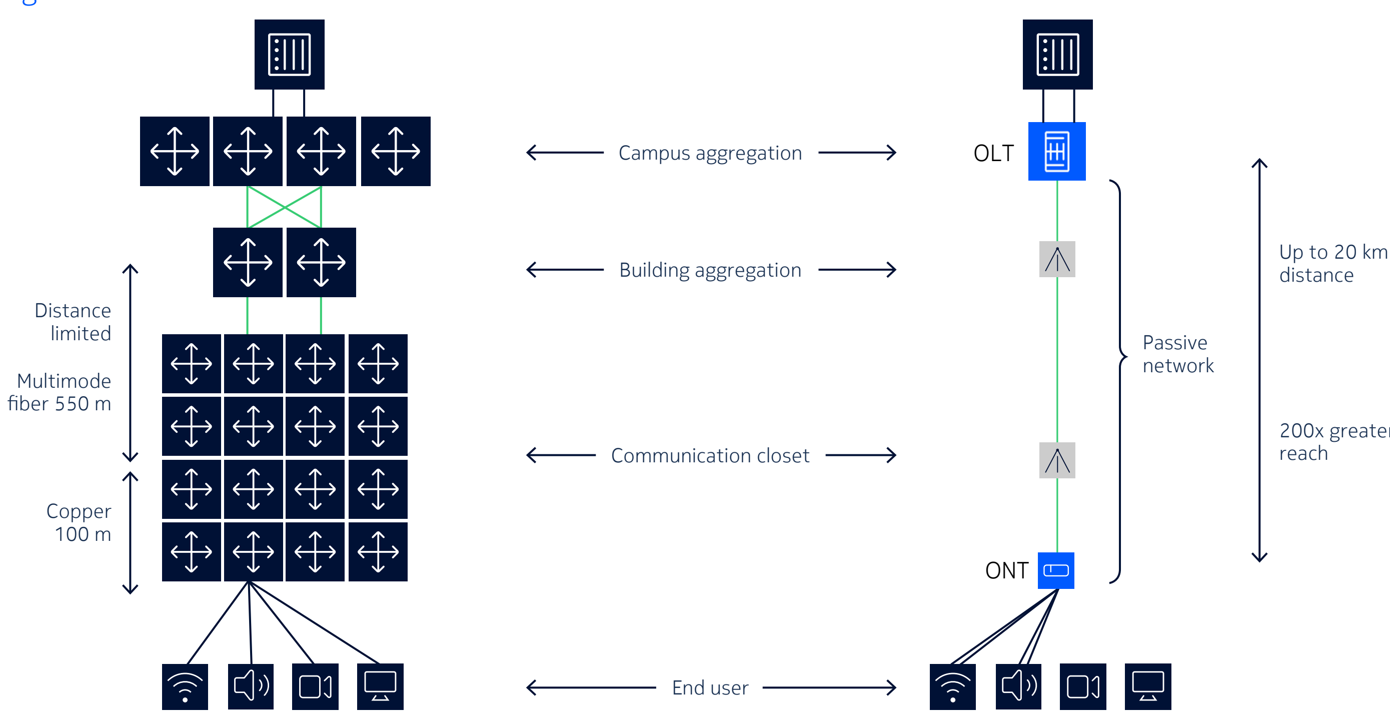


Typically, the length of a copper cable link between two active devices in an enterprise installation is restricted to a maximum of 100m for Cat 5 and Cat 6. This allows for 90m of solid core permanent wiring, two connectors and two stranded 5m patch cables at each end. Exceeding the maximum cable/patch 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.

Optical LAN offers enterprises a better networking option compared to copper because it is built on fiber optic cabling, which gives fiber-based LAN networks a significantly higher reach compared to copper cabling (up to 20km compared to less than 100m for higher speeds). This allows for a flatter, more centralized LAN design where the key element placements are not limited by the distance or IT room availability and bandwidth constraints of twisted pair copper wiring. 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. 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 Optical LAN infrastructure has a smaller equipment footprint compared to a copper-based 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 an 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. In addition, it contributes to sustainability and environmental, social, and governance (ESG) objectives.

Figure 2. Traditional LAN architecture versus POL architecture



Technology

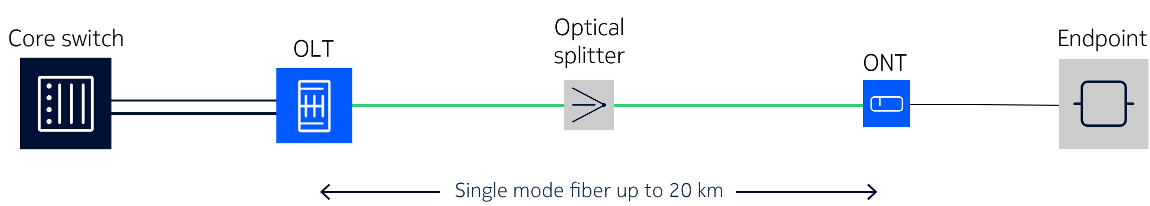
The centralized architecture in an enterprise network built on Optical LAN is enabled by Passive Optical Network (GPON) technology that has been deployed successfully for residential, business and mobile backhaul applications for decades. It delivers all services over an optical fiber.

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. 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, an Optical LAN enabled by PON consists of:

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

Figure 3. Core elements of an Optical LAN



The OLT is the central switch 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 an Optical LAN, compared to a traditional copper-based 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 that provide multiple Ethernet ports, analog voice 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, PON technology provides a massive amount of bandwidth with (i) GPON - 2.5 Gb/s downstream and 1.25 Gb/s upstream, (ii) XGS-PON – 10Gb/s downstream and 10Gb/s upstream, and (iii) 25GS PON – 25 Gb/s upstream and 25 Gb/s downstream – without removing the underlying network infrastructure.

The carbon footprint of manufacturing fiber is only a fraction of copper cables. The CO_2 emissions needed for a single core fiber is only 2% of that needed to make a Cat 7 cable of the same length (data is derived from our LCA calculator tool using Sphera database).

Converting to optical LAN

Optical LAN is the ideal alternative for enterprises considering an upgrade to their installed copper-based LAN 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 ten years from installation. On the other hand, a Optical LAN installation can be more cost effective, greener 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 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 the introduction of next generation fiber technologies like XGS-PON, 25G PON and beyond. Consecutive generations of PON technology can be deployed on top of GPON and coexist on the same fiber. Therefore, enterprises investing in Optical LAN networks can evolve to next generation PON using the same fiber, splitters and OLT. Furthermore, upgrades to XGS-PON and 25G PON in the future can be applied gradually. The technology allows enterprises to introduce e.g. XGS-PON 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 Optical LAN can remain in operation for decades without any significant cabling upgrades, whereas a copper-based LAN must be upgraded with every new cabling standard.

By upgrading the active components of the entire passive network, one is advocating for a circular approach that extends the lifespan of current components and diminishes electronic waste by reducing the quantity of active components within the network.

Operating advantages

An enterprise network built on Optical LAN also offers a number of operating advantages. The coverage area for copper-based 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, Optical LAN provides coverage for distances up to 20km. A single energy-efficient fiber-based central switch 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 an Optical LAN. The entire network can be easily managed from one point, using an integrated management platform or user-friendly Web interface.

Finally, Optical LAN contributes to green ICT operations because it requires 90 percent less floor space and consumes roughly 40 percent less power compared to a copper-based LAN 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 Optical LAN can enable enterprises to meet and exceed green certification initiatives, such as Leadership in Energy and Environmental Design (LEED) certification or Building Research Establishment Environmental Assessment Methodology (BREEAM) certification.

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 LAN networks.

Enterprises can get more value from an Optical LAN network that is engineered from the ground up and that will last for decades. They can leverage the benefits of proven PON technology that offers unlimited bandwidth potential to deliver all services at 2.5Gb/s upstream and 1.2Gb/s downstream today, and as high as 25Gb/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.

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
XGS-PON	10 Gigabit Symmetrical Passive Optical Network
25G PON	25 Gigabit Passive Optical Network
LAN	local area network
LEED	Leadership in Energy and Environmental Design
BREEAM	Building Research Establishment Environmental Assessment Methodology
ODN	optical distribution network
OLT	optical line terminal
ONT	optical network terminal
OPEX	operating expenditures
POL	passive optical LAN
UPS	uninterruptible power supply

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