Addressing issues in the local area network

Enabling the digital and sustainable enterprise with Optical LAN

Strategic White Paper

For more than 30 years, the local area networks (LANs) that enable enterprise business have been built on successive generations of enterprise LAN technology. Although this technology continues to evolve, the limitations of the twisted pair, copper-based wiring at the heart of the standard are causing enterprises to look at alternative options for their next-generation LAN infrastructures. Passive optical LAN (POL) technology eliminates the networking limitations imposed by traditional copper-based networks. It addresses the evolving service demands of enterprises with fiber optic cabling that delivers all services on one efficient, energy-conscious, high-capacity network. This paper examines the limitations of traditional enterprise networks built on traditional copper-based LAN technology and presents the benefits of an enterprise-level Optical LAN.

Contents

Introduction	3
Limitations of copper-based LANs	3
Eliminating enterprise network challenges with Optical LAN	5
Summary	7
Acronyms	7

Introduction

The digital and sustainable enterprise of the 21st century will require very different information and communications infrastructures. To support a more inclusive way of working, the network will have to be flexible enough to enable employees to define their own working environment. Employees will need to move freely on-site and off-site while maintaining connections with colleagues, partners and suppliers. The network will have to provide ubiquitous, always-on connectivity to support a range of applications, such as Wi-Fi 7, 5G, IoT, workplace virtualization, cloud applications, video collaboration and immersive communications. Moreover, it will have to support increasing bandwidth demands, multi-gigabit connectivity and lowering the environmental footprint.

As enterprises move toward the next generation of communications and collaboration, LAN networks designed to support 10/100 Mb/s services with Cat 5/Cat 6 cabling are no longer enough. Enterprises need a new future-ready solution that will address today's requirements and eliminate the need for costly upgrades tomorrow.

This paper examines the limitations of traditional enterprise networks built on copper-based Ethernet technology and presents the benefits of enterprise-level -Optical LANs.

Limitations of copper-based LANs

For more than 30 years, the LANs that enable enterprise business have been built on successive generations of copper-based Ethernet technology. Evolutionary changes in this staple of enterprise LANs have focused on providing faster speeds and meeting the increasing information management requirements of the ever-changing enterprise. Although this technology continues to evolve, the limitations of the twisted pair, copper-based wiring at the heart of the standard are causing some enterprises to look at alternative options for their next-generation LAN infrastructures.

Performance limitations

Typically, most enterprises operate multiple communication and information networks with separate cabling for voice, video, data, surveillance, access control, security, Wi-Fi and 5G services. However, traditional copper-based Ethernet LANs do not have the bandwidth and capacity to support the requirements of the emerging digital enterprise. Enterprises routinely exchange large amounts of data both internally and externally, and heavy usage combined with high-bandwidth applications slow legacy LAN performance.

Granted, the data transfer speeds in copper-based LANs have increased significantly since the standard was first ratified in 1983 with speeds now of 1 Gb/s to 10 Gb/s available. The frequencies needed to enable the higher transfer speeds must be supported by more sophisticated cable construction techniques as well as enhanced enterprise switches. In some cases, more advanced noise canceling is required to filter out the cross-talk interference between cables and neighboring equipment that use electromagnetic pulses. Thus, to take advantage of the additional speed enterprises have to remove and replace existing cables and switches, which were not engineered for transfer rates beyond 1 Gb/s.

Meanwhile, the increasing reliance on mobility is placing added pressure on copper-based LANs. With Wi-Fi and 5G now an integral part of every enterprise communications infrastructure, the capacity and bandwidth limitations are even more obvious.

Given the ubiquity of wireless devices in an enterprise and the popularity of bring your own device (BYOD) policies, many enterprises may soon find that the wired infrastructure upon which their wireless networks are built is no longer able to handle the traffic volume being generated and unable to match the speed demands of the devices connecting to it. As enterprises adopt the latest Wi-Fi and 5G standards, enterprise LANs must be adapted to support beyond 1 Gb/s and will have to continue to scale bandwidth to adhere to evolving Wireless standards.

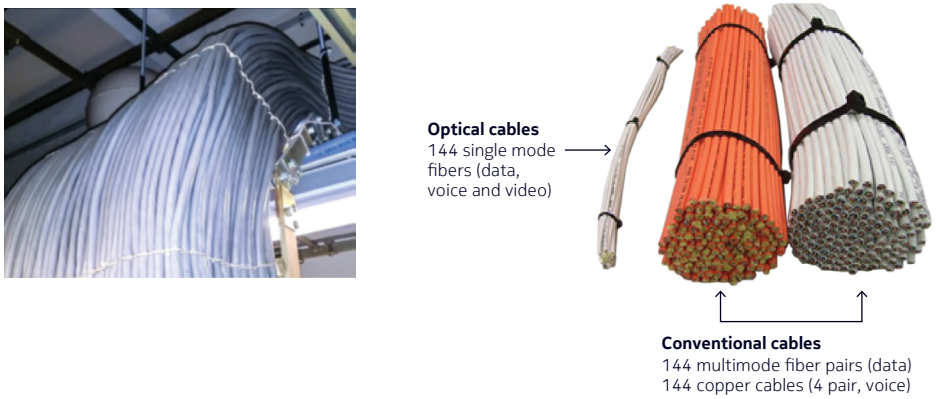
Physical limitations

In addition to performance, the physical limitations of copper-based Ethernet LANs create significant challenges for enterprises.

High-frequency signals transmitted over copper wire degrade as they travel over longer distances. Therefore, the length of a copper cable link between two active devices in an enterprise installation is restricted to a maximum of 100 m for Cat 5 and Cat 6. This allows for 90 m of solid-core permanent wiring, two connectors, and two stranded patch cables of 5m at each end. Exceeding the maximum cable length or patch cabling length will cause signal loss. As a result, installers must add active hardware such as repeaters or switches for longer runs. This limitation is even more restrictive for other cabling. For example, although cable links between two active devices using Cat 6A cable are possible up to 100 m, some manufacturers recommend restricting cable lengths from 35m to 40m for higher performance applications.

Obviously, these restrictions can lead to complex and bulky installations (see Figure 1). In enterprises with multiple independent networks the weight of the copper cables alone can be significant. For example, 300 m of Cat 6 cable weighs about 10.8 kg, while the weight of the same length of Cat 6A cabling is about 22 kg.

Figure 1. Length restrictions for Ethernet cable create complex and bulky installations



Installations are further complicated by the fact that high-frequency signals transmitted over copper are very sensitive to noise or interference generated by other cables or devices. Consequently, copper installations must be planned carefully to avoid signal interference. category (CAT) cables must be kept away from all power wires and must be orthogonal to power cables when crossing power wires.

In addition, the copper cables must be handled carefully during installation. Installers should not exceed the recommended bend radius for Cat 5, Cat 6 and Cat 6A cables and be careful to not exceed pulling force limits when drawing cables through cable trays as this can damage the cable. This increases the time and cost for the copper-based LAN installation process.

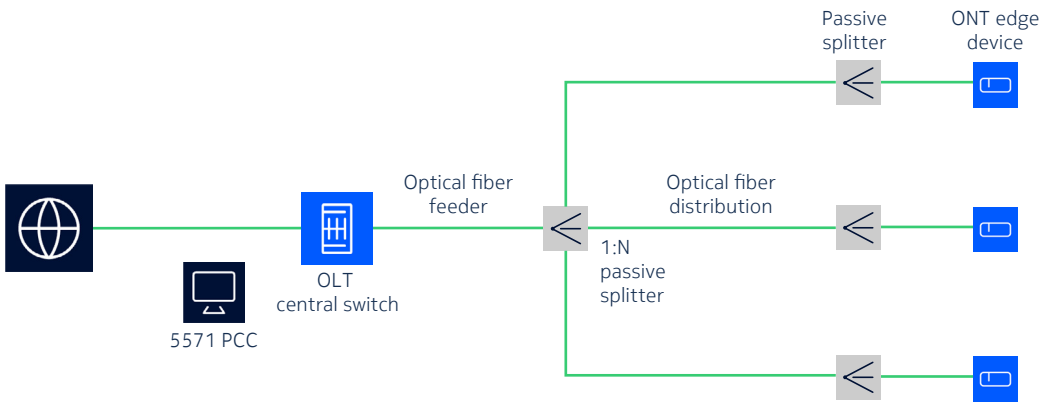
Eliminating enterprise network challenges with Optical LAN

Optical LAN technology eliminates the networking limitations imposed by traditional copper-based networks. It addresses the evolving service 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 while generating substantial environmental advantages.

Deployment flexibility

An enterprise Optical LAN solution uses Passive Optical Network (PON) technology that has been deployed successfully worldwide for residential, business and mobile backhaul applications for decades, adapting it for the enterprise environment (see Figure 2). It is built on fiber optic cables, which are cheaper and significantly thinner and lighter than Cat 5 and Cat 6 cables.

Figure 2. Optical LAN for enterprise



PON key facts	
Bandwidth per PON	GPON: 2.65 Gb/s downstream and 1.2 Gb/s upstream XGS-PON: 10 Gb/s downstream and 10 Gb/s upstream
Bandwidth per user	+1 Gb/s
Outside plant	Passive Split ratio: 1:128 Reach: 20 km
Services	Voice, data, video, IoT, cloud-based applications, Wi-Fi 7, 5G, etc.
Evolution	Graceful migration to 25G PON in the future

Fiber cables are also more flexible, more resistant to physical and environmental elements (such as EMI and corrosion) and carry less fire load than their copper counterparts. They offer virtually unlimited capacity, so enterprise networks built on Optical LAN require fewer cables to connect all users and deliver all service types. Ultimately, all these physical characteristics make fiber easier to install and reduce initial capital expenditures, as well as deployment and installation costs.

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) Operational and environmental efficiency.

Operational and environmental efficiency

With a POL there are fewer active electronics on-site. All office department communications and information systems are integrated onto one infrastructure that can be managed from one central location.

Higher performance

An enterprise fiber-LAN network is also more efficient with bandwidth because PON technology supports a wide range of voice, data and video applications. Using PON dynamic bandwidth allocation (DBA) schemes and distributed splitting architectures (1:2 to 1:128 split), quality of service (QoS) guarantees can be easily achieved for high bandwidth and mission-critical applications.

With Optical LAN delivering enormous amount of bandwidth, with GPON - 2.5 Gb/s downstream and 1.25 Gb/s upstream – and XGS-PON – 10Gb/s downstream and 10Gb/s upstream — over a single strand of glass, every enterprise is better equipped to process the increasing volume of digital communications and information that must be managed efficiently every day. Data processing requirements will continue to increase as enterprises strive to support more transactions enabled by a variety of multimedia devices. Businesses that work with complex digital files, such as healthcare, 3D design, ultra-high resolution, digital imaging or giga/terabytes-video production files will probably require even more bandwidth in the future.

An enterprise Optical LAN can address these requirements with GPON and XGS-PON today and an easy migration to 25G PON technology tomorrow on the same fiber infrastructure. Optical LAN can provide all the high bandwidth needed for productive and sustainable growth without costly upgrades.

Scalability

After the Optical LAN infrastructure is installed — whether for a new network (greenfield) or as part of a network renovation (brownfield) — it will last and be sufficient for decades to come, ready to support any new service that may come along. Moreover, to ensure scalability the ITU-T has standardized PON to support future evolution with 25GS PON. This standard will provide enterprises that deploy Optical LAN a smooth evolution of their LAN networks from GPON to 25G PON symmetrical bandwidth capacity on the same cable infrastructure, with minimal changes in electronics and take their networks a long way.

If higher bandwidth is required in the future though, the upgrade will be easy and cost effective. There will be no need for forklift upgrades. Expansions of new floors or facilities would be possible by simply extending the fiber and adding optical network terminals (ONTs) — no major cable runs or additional copper-based switches or ports would be needed.

Security

Finally, an Optical LAN provides a higher level of security for network traffic compared to traditional copper-based networks. Fiber-based enterprise architectures are more secure from the distribution layer to the access layer because the centralized architecture provides encryption to all downstream traffic with GPON, and downstream and upstream traffic with XGS-PON and 25G PON. Optical LAN is built with intrusion detection systems, which prevent physical tampering, and it limits the type of systems that can connect to the fiber. More importantly, light wavelengths are insensitive to snooping or interception.

Summary

Ultimately, an enterprise Optical LAN infrastructure provides more value for less investment compared to traditional copper-based networks. It allows enterprises to leverage the efficiency of optical fiber to:

- Provide a premium service experience. Optical LAN delivers multi-gigabit speeds and protects sensitive data with built-in, military-grade security features.
- Reduce costs by delivering all services on one efficient, high-capacity network. Optical LAN reduces operating costs by using equipment that requires less power, cooling and maintenance. This equipment also uses less space and covers 200x more area than legacy LAN equipment.
- Decrease the carbon footprint accomplished by employing more efficient and fewer active components in the network infrastructure, while also promoting circularity through simplified upgradability. Furthermore, this strategy aids in the reduction of electronic waste by minimizing the quantity of active components utilized in the network

Most importantly, a fiber-based enterprise LAN can deliver value to an enterprise for more than 50 years. Optical fiber cables are more resistant and longer lasting than copper cables. They offer unlimited bandwidth potential and they support cost-effective network evolution by allowing businesses to reuse cables and central switches for new services and bandwidth increases as needed. This service is enabled by high-capacity PON technologies like GPON and XGS-PON, and 25G PON in the future. Enough to support the needs of businesses and their employees for years to come with little or no changes to electronics and cabling.

Acronyms

BYOD	bring your own device
DBA	dynamic bandwidth allocation
GPON	Gigabit Passive Optical Network
XGS-PON	10 Gigabit Symmetrical Passive Optical Network
25G PON	25 Gigabit Passive Optical Network
LAN	local area network
OLT	optical line terminal
ONT	optical network terminal
OL	Optical LAN
QoS	quality of service

About Nokia

At Nokia, we create technology that helps the world act together.

As a B2B technology innovation leader, we are pioneering networks that sense, think and act by leveraging our work across mobile, fixed and cloud networks. In addition, we create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.

Nokia OYJ
Karakaari 7
02610 Espoo
Finland
Tel. +358 (0) 10 44 88 000

Document code: (May) CID193645