NOKIA

Addressing issues in the local area network

Enabling the digital enterprise with passive 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 Ethernet technology. 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. Passive optical LAN (POL) technology eliminates the networking limitations imposed by traditional copper-based Ethernet. It addresses the evolving service demands of enterprises with fiber optic cabling that delivers all services on one efficient, high-capacity network. This paper examines the limitations of traditional enterprise networks built on Ethernet technology and presents the benefits of an enterprise-level POL.

NOKIA

Contents

NOKIA

Introduction

The digital enterprise of 2020 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 workplace virtualization, cloud applications, video collaboration and immersive communications. Moreover, it will have to support increasing bandwidth demands and multi-gigabit connectivity.

As enterprises move toward the next generation of communications and collaboration, LAN networks designed to support 10/100Mb/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 Ethernet technology and presents the benefits of enterprise-level POLs.

Limitations of Ethernet LANs

For more than 30 years, the LANs that enable enterprise business have been built on successive generations of Ethernet technology. Evolutionary changes in this staple of enterprise LANs have focused on providing faster speeds, less noise, and more efficient signaling to meet 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 and Wi-Fi services. However, traditional 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 Ethernet LANs have increased significantly since the standard was first ratified in 1983 with speeds now of 1Gb/s to 10Gb/s available. The frequencies needed to enable the higher transfer speeds must be supported by more sophisticated cable construction techniques. 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 1Gb/s.

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

Many of today's Wi-Fi access points are engineered to support up to 1Gb/s; however, new 802.11ac access points are designed to support 1.5Gb/s. 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 802.11ac Wi-Fi standard, enterprise LANs must be adapted to support 1Gb/s. Bit-rate requirements will be higher with 802.11ac Wave 2 and enterprise LANs will have to continue to scale bandwidth to adhere to evolving Wi-Fi standards.

Physical limitations

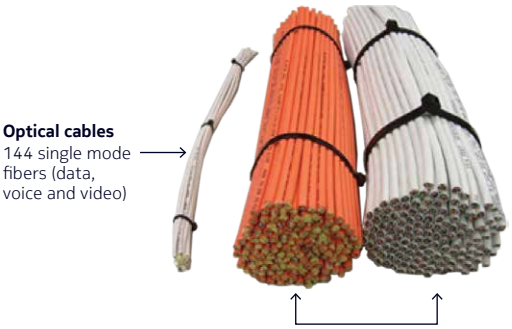
In addition to performance, the physical limitations of copper-based Ethernet create significant challenges for enterprises.

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 100m for Cat 5 and Cat 6.[1] This allows for 90m 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 100m, some manufacturers recommend restricting cable lengths from 35m to 40m for higher performance applications.

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

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, 300m of Cat 6 cable weighs about 10.8kg, while the weight of the same length of Cat 6A cabling is about 22kg.

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 generated by other cables or devices. Consequently, copper installations must be planned carefully to avoid signal interference. Ethernet cables must be kept away from all power wires and must be orthogonal to power cables when crossing power wires. In addition, the Ethernet 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 Ethernet LAN installation process.

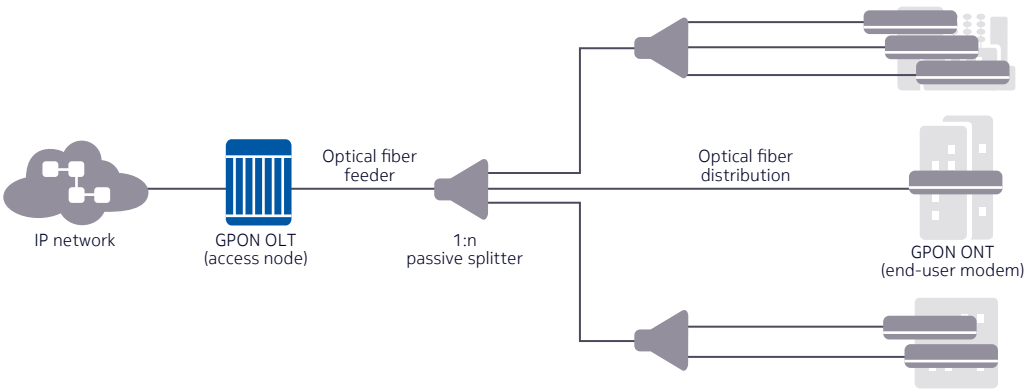
Eliminating enterprise network challenges with POL

Passive optical LAN technology eliminates the networking limitations imposed by traditional copper-based Ethernet. 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.

Deployment flexibility

An enterprise POL solution uses Gigabit Passive Optical Network (GPON) technology that has been deployed successfully worldwide for residential, business and mobile backhaul applications, 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. POL for enterprise



GPON (ITU-T G.984) key facts	
Bandwidth per PON	Downstream: 2.5Gb/s; upstream: 1.2Gb/s
Bandwidth per user	1Gb/s
Fiber	Passive; max. split 1:128; reach: 20km in one direction
Services	Data, voice, video, Wi-Fi backhaul
Evolution	Graceful migration to TWDM-PON 40Gb/s symmmetrical

Fiber cables are also more flexible, more resistant to physical and environmental elements, and carry less fire load than their copper counterparts. They offer higher capacity than copper, so enterprise networks built on POL 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.[2]

Operational 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.

2 TE Connectivity, 2011. “Optical LAN Solutions (OLS): Capabilities Overview and Fast Facts.”

Higher performance

An enterprise POL network is also more efficient with bandwidth because GPON technology supports a range of voice, data and video applications. Using GPON 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 a POL delivering up to 2.5Gb/s bandwidth to the desktop, every user 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 for architecture, 3D design, animation and digital imaging, will probably require even more bandwidth in the future.

An enterprise POL can address these requirements with up to 2.5Gb/s to the desktop today and an easy migration to 10Gb/s or 40Gb/s tomorrow on the same fiber infrastructure. A POL can provide all the high bandwidth needed for productive and sustainable growth without costly upgrades.

Scalability

After the POL infrastructure is installed — whether for a new network or as part of a network renovation — 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 time and wavelength division multiplexing PON (TWDM-PON). Today, this standard will provide enterprises that deploy POL a smooth evolution of their LAN networks from 2.5Gb/s downstream and 1.25Gb/s upstream to 40Gb/s symmetrical per system (4 x 10G over different wavelengths) on the same cable infrastructure and with minimal changes in electronics.

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 rooms or facilities would be possible by simply extending the fiber and adding an optical network terminal (ONT) — no major cable runs or additional Ethernet switches or ports would be needed.

Security

Finally, a POL provides a higher level of security for network traffic compared to copper-based Ethernet networks. An independent study concluded that 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. The study noted: “A simple

checkbox on the OLT and all communications downstream to ONT systems is encrypted, which is a leap forward in communications."[3] In addition, the study emphasized that a POL 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 POL infrastructure provides more value for less investment compared to traditional copper-based Ethernet networks. It allows enterprises to leverage the efficiency of optical fiber to:

- Provide a premium service experience. A POL delivers 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. A POL 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.

Most importantly, a fiber-based enterprise POL 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 access nodes for new services and bandwidth increases as needed. This service is enabled by the high-capacity GPON technology that can deliver 2.5Gb/s upstream and 1.2Gb/s downstream — enough to support the needs of businesses and their employees for years to come. Lastly, as bandwidth demand grows, GPON can be easily migrated to next-generation PON technology, TWDM-PON, and accommodate bandwidth increases in manageable increments with little or no changes to electronics and cabling.

3 SANS Institute, 2013. "Comparative Risk Analysis Between GPON Optical LAN and Traditional LAN Technologies."

Acronyms

BYOD	bring your own device
DBA	dynamic bandwidth allocation
GPON	Gigabit Passive Optical Network
LAN	local area network
OLT	optical line terminal
ONT	optical network terminal
POL	passive optical LAN
QoS	quality of service
TWDM-PON	time and wavelength division multiplexing PON

Additional sources

1. The Association for Passive Optical LAN. “Passive Optical LAN Overview and Benefits” (http://www.apolanglobal.org/resources/).
2. The Fiber Optic Association. “Guide to Fiber Optics & Premises Cabling” (http://www.thefoa.org/tech/ref/contents.html).

Nokia Oyj
Karaportti 3
FI-02610 Espoo
Finland
Tel. +358 (0) 10 44 88 000

Product code: PR1602017988EN