Why Fiber Optical LANs Are the Better Choice for High-Performance Green Buildings

Introduction

Interest in high-performance "green" buildings has grown significantly in the last 20 years. High-performance buildings are less expensive to maintain and require less energy to operate. The cost savings and public relations benefits of high-performance buildings can be significant, and many organizations are aggressively implementing policies to make their buildings more energy efficient and sustainable.

In order for businesses, colleges, hotels, hospitals, government agencies and other organizations to maintain high-performance buildings, IT management must play its part. You are responsible for evaluating the performance of your systems to determine if a better, more energy-efficient alternative exists. One such system is your local area network (LAN). Are you deploying the most energy-efficient LAN? Most organizations run either a copper-based active Ethernet LAN or a fiber Optical LAN. But which one is the better choice for high-performing buildings?

This document will compare the two LAN technologies and explain why fiber Optical LANs, based on passive optical network (PON) technology, are the lower-cost, energy-efficient alternative to copper-based active Ethernet LANs. Optical LANs deliver the cost-effective, low-energy, small form-factor infrastructure that directly impacts eco-friendly, high-performance building initiatives.

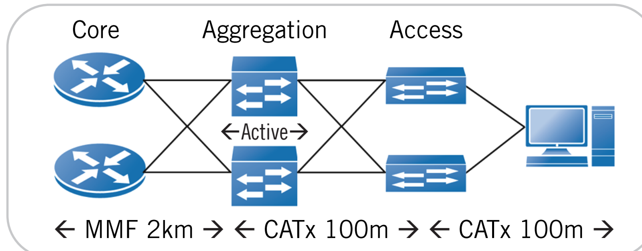


Figure 1. Copper-based active Ethernet LAN

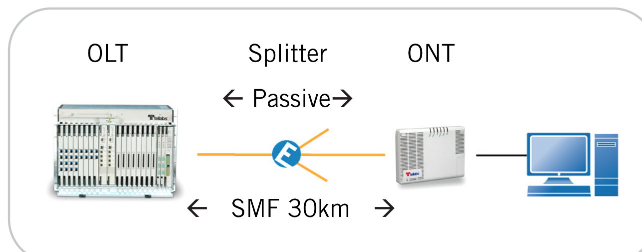


Figure 2. Fiber-based Optical LAN

LAN Design: Active Ethernet LAN vs. Optical LAN

Traditional copper-based active Ethernet LAN design is a fully meshed hierarchy of energized electronics providing Ethernet switching functions at the core, aggregation and access positions of a building LAN (Figure 1). Often there are multiple cable infrastructures serving overlay networks for data, voice and video. These copper-based infrastructures use CAT, twisted pair or coax for cabling, and if fiber is used, the optical services are deployed using multi-mode fiber (MMF).

Fiber-based Optical LAN leverages the inherent benefits of PON with a centrally located optical line terminal (OLT) at the core, and passive optical distribution splitters at the aggregation and optical network terminations (ONT) position at the access (Figure 2). Optical LAN uses a single mode fiber (SMF) for in-building and across-campus cabling that converges all building ICT services, such as voice, video, data, wireless access, security, surveillance and building automation, over a single infrastructure.

Studies have shown that fiber access for telecommunications service providers can reduce resource depletion, greenhouse gas emissions, carbon footprint and the release of toxins into the environment.[1] Optical LAN exploits these same factors and applies them to high-performance buildings.

Cost-Saving Benefits of Optical LAN

In a direct comparison, Optical LAN outperformed traditional copper-based active Ethernet LAN design relative to equipment CapEx, OpEx and fiber-based cable infrastructure.

Equipment CapEx Savings

Optical LAN has enjoyed up to 70% CapEx savings when compared to the copper-based alternative. Not all configurations result in such great savings, but at the simplest level, it is intuitive that with less electronics in the network, you spend less on equipment. Another benefit of Optical LAN is the fact that a single OLT, single ONT and single SMF ODN infrastructure achieves 99.999% reliability. To achieve the same level of reliability, active Ethernet LANs require fully meshed, fully redundant electronics at core, aggregation and access, and even redundant optical network interface cards (NICs) at workstations.[2]

Another factor that drives separation in cost is Optical LAN's efficient support for VoIP and analog POTS phones, and IP and RF video. Optical LAN can provide cost-effective hybrid network architectures that serve analog POTS phones and RF video over the same SMF cable infrastructure with concurrent service delivery (i.e., both VoIP and POTS phones, and IP and RF video simultaneously).

Equipment OpEx Savings
Optical LAN requires less equipment than copper-based Ethernet LAN, which means fewer electronics to maintain. It also means fewer recurring annual right-to-use and service support agreements, whose fees can be as much as 80% higher than the comparable fees associated with an Optical LAN solution.

Centralized control through an element management system, instead of accessing network elements locally through the craft user interfaces, significantly reduces OpEx. Instead of many IT support personnel fanning out to manage nodes spread out across the facility, Optical LAN emphasizes centralized management through an intuitive graphical user interface. IT departments with limited resources and constant time constraints will benefit from this efficient means of provisioning and administering adds, moves, changes and software upgrades. Unfortunately, large organizations lose approximately 3.6% annual revenue due to network downtime, and human error is responsible for 50% to 80% of outages.[3] Thus, there are benefits to prioritizing machine-to-machine and centralizing management as much as possible.

Optical LAN also offers lower initial training costs, plus annual training refresh certifications at no cost. Optical LAN training is typically completed after one week of classroom time, compared to weeks of commitment for active Ethernet training programs (e.g., CCNx certification) and annual refresh work. For example, after just 5 days of Optical LAN training, specialists have the knowledge they need to operate the Optical LAN OLT, ONT and EMS. Considering that the biggest expense of active Ethernet certification courses is not their cost, but rather the travel expense and lost hours away from daily work duties, Optical LAN training is certainly more cost effective and a more efficient use of staff time.

Cabling CapEx Savings
Optical LAN and SMF gain CapEx savings relative to traditional copper-based active Ethernet LAN based on lower material and installation costs.

Relative to material cost savings, a TE Connectivity study compared SMF ($0.089 per lineal foot) and CAT6 ($0.35 per lineal foot) and MMF ($0.45 per lineal foot) and showed a substantial savings with Optical LAN SMF.[4]

Today's bend-resistant fiber solutions are trending toward ever-easier installations, plus pre-terminated solutions now provide rapid and cost-effective installations. In a recent study, Corning concluded that in many cases fiber solutions are less costly than copper for inside-building LAN infrastructure.[5] By combining the on-site SC/APC connector system's fast installation with no-fusion splicing, bend-resistant fiber, and ornamental wall molding with adhesive backing solution, 3M was able to cut their installation costs in half for existing facilities' LAN cable infrastructure upgrades.[6]

Furthermore, SMF's resistance to electromagnetic interference (EMI), radio frequency interference (RFI) and crosstalk significantly reduces the design and installation requirements around power cables. Lighter and stronger SMF uses J-hook installation instead of cable trays and conduit. Each of these factors further reduces the cost of cable infrastructure installation.

Energy Savings for Greener Buildings

Customer-generated business cases have shown that Optical LAN can reduce power consumption by up to 80% using OLT and ONTs instead of a traditional copper-based active Ethernet LAN.[7] With a fully meshed hierarchy of active Ethernet switches, energy is consumed every time an optical-to-electrical conversion or electrical-to-optical conversion occurs. With fewer such conversions, a passive optical network will consume less energy.[8]

When the energy savings of Optical LAN is reviewed, it is easy to see the rippling effect of the savings relative to electrical (plug load) and thermal (HVAC) load design of the total building. For example, 1 watt of electricity consumption saved in a data center results in 2.4x savings throughout the entire building. This is a direct result of needing less DC/DC, AC/DC, power distribution, and transformer, generator and battery backup. From a thermal standpoint, the Optical LAN's lower energy consumption requires less HVAC capacity. Forward-looking building design could even use temperature-hardened OLT in data center/telecom closet and use only fresh air ventilation, eliminating any need for forced air conditioning.

With all the great energy savings Optical LAN offers, it is easy to extrapolate the corresponding reductions in carbon emissions. For example, a 2,000 endpoint Optical LAN building saves 28 KWH. Converting KWH to CO2, that building saves 165 tons of carbon emissions per year.[9]

Space/Material Reduction

Equipment Impact
Optical LAN provides superior density, with 8,192 IP/Ethernet endpoints being served by one Optical LAN OLT occupying 9 rack units or 15 ¾ inches (Figure 3). In comparison, an active Ethernet node that serves 2,016 IP/Ethernet endpoints occupies 90 rack units or 157 ½ inches. Furthermore, ODN splitters eliminate the need for active electronics used in the aggregation sector of this LAN, thus eliminating telecom closets/IDF. Eliminating active electronics reduces space, power and thermal demands in the main data center/MDF. It also reduces requirements for space, power, thermals and telecom closets/IDF throughout the building.

Another advantage is Optical LAN's ability to converge services efficiently. This single network infrastructure can support voice (IP or POTS), data, video (IP or RF), wireless access points, building security, surveillance and automation.

Such efficiency makes Optical LAN an excellent choice for buildings that have restricted space. For example, Optical LAN is ideal for buildings with challenging cable access points, especially retro-fits projects and historic preservation projects.

Cabling Impact

SMF provides the best future-proof all-fiber LAN infrastructure choice. In contrast to MMF and CATx cabling, SMF has enjoyed stable industry standards in recent years and holds the best promise for supporting future technologies (e.g., 10GbE GPON, WDM PON, 40GbE, 100GbE). For example, in March 2010, NTT demonstrated the ability to transport 69 Tbps of data over a single 240km-long SMF.

CATx cabling standard has been less stable, with more than five variations defined in the past 10 years (e.g., 3, 5, 5e, 6, 6a, 7, etc.). SMF is smaller, lighter and stronger; it has a tighter bend radius; offers higher bandwidth, longer reach, better EMI/RFI, faster connectors, longer life and is less expensive than CATx. Relative to Optical LAN, a single SMF strand can carry services to 128 IP/Ethernet endpoints, while CATx often carries to only one. Considering environmental factors, copper-based products consume 100x to 200x more natural resources than glass-based products.[10]

Similar to CATx industry standards, MMF standards continue to evolve and struggle to keep pace with today's technologies and bandwidth capacity requirements (i.e., OM1 to OM4). MMF optics may promise lower costs and lower energy use, but when calculating cost/power across an end-to-end network, Optical LAN still proves better. MMF's main weaknesses are its lower bandwidth capacity and short reach when compared to SMF. For example, MMF does not support DWDM and 100GbE demos have been over four fibers.

Impact on High-Performance Buildings

All of these benefits of Optical LAN and SMF affect the design of high-performance buildings. Less active electronics and smaller form-factor equipment mean less power required by data center/MDF and telecom closets/IDF, which reduces the overall power load to the building. Less thermals at data center/MDF and telecom closets/IDF lowers HVAC load. Finally, smaller data center/MDF and fewer telecom closets/IDF reduces demands on the HVAC/power load as well. Fewer cables and smaller cable means less plastics, thus less smoke load on the building. Fewer floor and wall penetrations equals reduced fire hazard (e.g., fire stopping).

In general, the gains in building floor space from Optical LAN enable real estate square footage to be repurposed for revenue generation, building amenities and building aesthetics. Dematerializing building infrastructure improves sustainability goals, since less material being used in a building can lead to the best possible cradle-to-grave life-cycle analysis. With this near future-proof LAN infrastructure, the number of technology refreshes is greatly reduced, resulting in significantly less waste (e.g., money, time, natural resources) over the long run.

Optical LAN Can Help with LEED Certification

Standards that govern the creation of high-performance buildings have been developed and managed by the U.S. Green Building Council.[11] Their program, called the Leadership in Energy and Environmental Design (LEED), sets the industry standard for developing high-performance buildings.

LEED covers new construction (including new development, major renovations, core and shell of building) and existing buildings (e.g., quantify and compare building operations, improvements and maintenance). LEED's goal is to maximize building operational efficiencies while minimizing environmental impact. LEED works on a system that awards points based on sustainability, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, innovation in operations and regional priority.

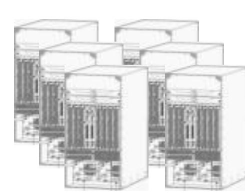
LEED-certified buildings are designed to lower operating costs, increase asset value, reduce waste sent to landfills, conserve energy and water, be healthier and safer for occupants and reduce harmful greenhouse gas emissions. Often LEED-certified buildings qualify for tax rebates, zoning allowances and other incentives.

Optical LAN can assist with LEED certification by:

- lowering operating costs
- increasing asset value
- reducing waste sent to landfills
- directly contributing to energy savings
- indirectly lowering thermal loads for HVAC
- reducing harmful greenhouse gas emissions.

Engineering and designing a building with Optical LAN can even result in additional LEED innovation bonus points.

Optical LAN
8,192 users
9 rack units



Ethernet LAN
2,016 users
90 rack units
3 equipment racks used

Figure 3. Comparing data center Optical LAN OLT size and density with active Ethernet LAN

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Value After LEED Certification

The ultimate goals of Optical LAN are to contribute to a high-performance building, increase building value and improve quality of user experience. Studies have shown that buildings with fiber connections sell with a 5% to 10% premium, and Optical LAN seeks to achieve that same value gain inside buildings.[12] An Optical LAN design can differentiate a building in order to attract and retain tenants/employees.

Once LEED certification is achieved, building owners, IT managers and tenants can reap the rewards of the measurable high-performance building (e.g., federal, state and local tax incentives and rebate/reimbursement/grant programs). There are even rebates to be gained through local utility companies. On average, LEED-certified new construction buildings achieve 30% better energy performance compared to similar non-certified buildings.[13]

Optical LAN buildings are well positioned to hold their value since technology upgrades are independent of fiber infrastructure—Optical LAN and SMF represent the best possible choice for future-proof LAN. For example, when/if the transition from 2.4GbE GPON to 10GbE GPON is executed, there are no wavelength conflicts between 2.4GbE GPON and 10GbE GPON. This will enable Optical LAN owners to utilize the same SMF and ODN splitter. With no wavelength conflicts, both 2.4GbE GPON and 10GbE GPON will be supported simultaneously on the same network and over the existing LAN infrastructure. Looking further into the future, the SMF is well suited to support future DWDM PON implementation, such as SARDANA.[14]

Summary

Optical LAN is the smart LAN option for high-performance green buildings. Fiber Optical LANs are more energy-efficient and environmentally friendly, and they take up less floor, rack and closet space than copper active Ethernet LANs. Organizations implementing high-performance building guidelines and applying for LEED certification should explore switching to an Optical LAN.

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