Fact or Fiction (Optical LAN Solutions) Make an Informed Decision
A White Paper about GPON in the LAN
Optical LAN is about Building the Future

Optical LAN Solutions (OLS)

Advances in technology — from simple handheld personal devices, to computers, to company network architectures — move at a torrid pace. Trying to keep pace with these advances has led to a convoluted array of racks, wires, patch panels, and switches. Today there is a better way to approach the design of network infrastructures.

Designing the Right Network

Designing a new network infrastructure or refurbishing your existing network is a significant investment. No doubt you have considered the challenges of traditional network designs; capacity, efficiency, security, scalability, capital investment, and green initiatives. Each of these challenges must be considered when designing a network solution to meet your requirements for decades to come. You need to design the right network ... the first time.

Optical LAN is the most cost effective, efficient and environmentally friendly alternative to existing copper based Ethernet Switch LAN infrastructure available in the market today…

Optical LAN is a high-performance, high density GPON based Optical LAN solution (OLS) delivering high speed data, voice and video to multi-level, multi-unit commercial and industrial complexes, including hotel rooms, educational, government, bandwidth demanding desktops and work-stations. Optical LAN can be deployed in offices, rooms, factories or other harsh industrial environments, delivering comprehensive connectivity for any Local Area Networking requirement.

Optical LAN is a next generation passive Optical network (PON) architecture built entirely on industry leading IT standards. This fully converged solution is scalable for a single building or large campus environments where customers are installing new facilities or upgrading their current LAN infrastructures. The solution provides a future-resistant LAN with environmentally friendly benefits, and high bandwidth capabilities to handle large sharing, file transfers, imaging, streaming video or real-time workgroup collaboration. Optical LAN Solutions are engineered to help improve network efficiencies, reduce capital costs, reduce space requirements, and conserve energy.

Improve Your Network's Efficiency

Designed as a layer 2 transport medium, Optical LAN delivers converged voice, video, and data services at Gigabit levels to the end user over a single strand of fiber; thus reducing your LAN infrastructure cabling and electronics to a fraction of what is required compared to a conventional Ethernet LAN

solution. Using PON technology we run single mode fiber that has the capability to handle 25 TeraHz worth of bandwidth throughout the building directly from the data room to the user's desktop or end destination. The single mode fiber deployed enables your network to reach end users located up to 12 miles from your datacenter with no need for signal regeneration.

Conserve Energy and Reduce Costs

As technology advances, so do ways to conserve energy and reduce operating costs. Optical LAN Solutions technology replaces conventional copper and multimode cables used with traditional network infrastructures to a single mode fiber optic cable allowing you to eliminate the traditional workgroup switches, patch panels, and racks in the riser closets. Depending on your network architecture requirements, implementing Optical LAN Solutions can offer substantial savings. Based on our analysis, compared to a workgroup switch-based Ethernet solution serving 1000 users, the Optical LAN Solution serving the same number of users significantly reduces:

- Power consumption by up to 90%.
- Space requirements by up to 90%.
- Green Efficiency up to an 85% improvement
- Capital costs related to network elements by up to 74%
- Cabling costs - single mode fiber is less expensive to procure than Multi Mode fiber or copper.

A Scalable and Secure Solution

As your capacity needs increase, you want your network to be able to expand without having to add costly equipment or risk security and quality issues. Fiber optic transport is seen as one of the most secure and advanced types of network communication methods available in the market today. Fiber optic cable neither emits nor radiates RF energy, making it very difficult to passively listen to or tap into your Optical circuit. And by utilizing 25 TeraHz fiber your network will be able to support advances in PON technology for years to come.

Optical LAN technology solutions optimized for enterprise LAN environments have become available only in the last couple of years from such companies as Zhone, Tellabs and Motorola. Yet, this technology — which enables a single-mode fiber-to-the-desktop architecture for the LAN – is quickly gaining traction in the market. Optical LANs are finding their place deeper within the LAN to meet the needs of very large and demanding Layer 2 switched applications.

- Scalability and reliability
- Ease of use and administration
- Energy savings and environmental sustainability
- High-bandwidth connectivity
- Advanced security
- Disruptively low total cost of ownership (savings in initial capital equipment cost

as well as ongoing operational cost).

Decision makers are increasingly choosing to forgo the status quo and take advantage of what Optical LANs have to offer for the long-term benefit of their organizations.

Mature and reliable technology

Optical LAN networking equipment is compliant to the ITU-T G.984 Gigabit Passive Optical Network (GPON) technology standard. PON technology was developed for and deployed in the U.S. by Verizon (for FiOS triple-play services) and by many other telecom operators around the world such as Etisalat deploying over 1 million ports of GPON to their subscribers delivering carrier-grade service to millions of subscribers while delivering advanced triple play services. In addition many service providers are deploying GPON for Mobile Backhaul and the newest consideration is GPON for “Small-cell” mobile backhaul for 4G services.

The FTTH Council Europe estimates that PON architectures currently make up 20% of FTTP/H access networks around the world, and that number is growing. And in the U.S., over 64% of broadband FTTH deployments use PON technologies, 51% of which is GPON. Optical LAN customers benefit from the widespread adoption of ITU G.984-compliant GPON equipment for FTTH in four ways.

1. Equipment prices are being driven down by world demand.

2. Optical LAN equipment has been designed to the highest specifications in the harshest outside plant environments and typically achieves the stringent so-called five-9s of reliability (99.999% uptime) to meet telecom operators’ standards. (Typically, Ethernet switches are designed to less stringent requirements.)

3. FTTH deployments have scaled to support millions of users and diverse services while enabling very efficient remote management and maintenance for the entire network via software features. Optical LAN vendors offer the same robust server and client network element management software (albeit with added enterprise-centric software enhancements) for the enterprise environment, which provides powerful operational, administration, and maintenance (OAM) functionality. In addition, Optical LAN vendors typically offer various scalable software licensing packages to optimize their offerings relative to the size of the network.

4. Environmental sustainability Optical LAN technology’s energy savings and environmental sustainability stem not necessarily from what it has, but from what it doesn’t have typical large Layer 2 switched Ethernet campus

network requires multiple levels of aggregation at the campus distributor, building distributor, and floor distributor/communications closet. Multiple layers of switches are required to aggregate the traffic back to the core-routed network. The layers are also required because the various cabling media choices used with traditional active Ethernet networks are limited in performance over a specified distance due to signal attenuation and other performance parameters (as per IEEE and TIA standards specifications). Cat 6A copper cabling for the horizontal links, for example, is specified to support 1 or 10 Gigabit Ethernet up to a 100-m limit (328 ft.), while multimode dual fiber connections for the backbone links can support 10 Gigabit Ethernet up to 2 km. In contrast, an Optical LAN network does not require any active components on any floor or even in each building. This is because single mode fiber communications media can support very high transmission speeds (in the terabits) over much longer distances – up to 20-30 km (over 12 miles) per industry standards specifications. Only a simple passive (non-powered) Optical splitter is needed to distribute and branch the communications signals to the Optical network terminals (ONTs) located in or near the work areas. The ONTs (also known as the workgroup terminals) come with various port configurations to support all services required, such as VoIP or POTS, IP/Ethernet data, analog or switched digital video, etc. For example, an ONT (shown in Figure 2) has four service ports of 10/100/1000 Base-T with IEEE 802.3at compliant Power over Ethernet (PoE) supported. Local AC power with optional battery and UPS can also be provided.

Instead of installing the typical two to four home-run copper cables from the communications closet to every work area, now only one lightweight, small-diameter single-fiber cable can be installed to the ONT, enabling considerable savings in infrastructure materials and installation labor. A streamlined Optical LAN architecture provides the following quantifiable benefits:

- Reduced HVAC requirements and costs for cooling racks of active electronics
- Reduced amount of UPS backup power required for centralized active electronics.
- Significantly reduced material in plastics and copper required for the infrastructure cabling, connectivity, and apparatus
- Reduced time to install, test, commission, and maintain the system.

Overall, the GPON Optical LAN solution typically requires lower power consumption on a per-Ethernet-port basis compared to the traditional active switched Ethernet networking approach.

High-bandwidth connectivity and considerations for Optical LAN With regard to bandwidth management, the Optical LAN system offers a unique, efficient, and optimized way to provide guaranteed bandwidth for various services while allowing up to 1-Gbps Ethernet connectivity and burst rate for many users. The Optical LAN system northbound connections to the core-routed

network are provided as multiple 1-Gbps or 10-Gbps Ethernet aggregated links up to 40 Gbps, while the service ports for the endpoint devices are typically standard 10/100/1000 Base-T Ethernet interfaces connecting to devices via regular RJ-45 copper patch cords (no PC fiber NIC cards required). Due to the inherently variable patterns required for different communications traffic as well as the specific bandwidth requirements based upon service types, Ethernet connections may at times require only low-bandwidth transmission, while at other times may require much more. The Optical LAN system enables network managers to specify and ensure a guaranteed bandwidth by the system via the committed information rate (CIR) setting to assure quality communications for real-time services. At the same time, the Optical LAN platform allows specified flows to burst up to the peak information rate (PIR) setting, which optimizes the dynamic distribution of bandwidth for each PON port (2.4 Gbps down/1.2 Gbps up) between many users, typically up to 32 or 64. The Optical line terminal (OLT) aggregation switch provides for non-blocking wire throughput of all the traffic across the LAN. The aggregated uplink connections to the core-routed network from the OLT are then chosen and sized to accommodate the guaranteed overall CIR for the system.

Stringent security required for the government Optical LAN technology uses the highly secure Advanced Encryption Standard (AES) 128-bit protocol as well as other advanced identification and authentication features. The Optical LAN platforms from some vendors have already passed the extensive information assurance test requirements of the U.S. Department of Defense Joint Interoperability Test Command (JITC). These tests evaluate security features of the network equipment and assess their ability to support critical and highly secure military and government agency networks. Focused government entities were, in fact, the initial requesters of the Optical LAN technology and were early adopters of it, beginning in 2009.

Meeting TIA standards Optical LAN is now supported by the Telecommunications Industry Association (TIA) 568-C.0 Generic Cabling Standards. On August 14, 2012, the TIA cabling standards organization approved and published Addendum 2 to the TIA-568-C.0 Generic Telecommunications Cabling for Customer Premise standard. In this officially approved update to the cabling standards document, the GPON approach has been added and categorized as a supported single mode fiber application for the LAN. The standard's channel definition now includes support for passive Optical splitters, which are a key component of the architecture. The Addendum 2 update calls for an Optical attenuation budget for the GPON Channel infrastructure of 13 to 28 dB, corresponding to the ITU-T G.984 GPON standard compliance requirements relative to the Class B+ Optical transmission characteristics. In addition, according to the ANSI/TIA 568-C cabling standards, copper cabling requires measured verification of no less than seven technology parameters for confirmation of the installed copper infrastructure performance characteristics. Testing is required for installed copper home-run cables to each

and every Ethernet device. On the other hand, Optical LAN infrastructure deployment requires only half to one-quarter the amount of horizontal runs and only one measured test parameter (Optical attenuation). Therefore, it will be far easier and take far less time to install and test than traditional balanced 100-Ohm copper structured cabling.

Who can benefit from Optical LAN? Optical LAN is well suited for almost any LAN deployments, where the scalable and immediate cost savings and longer-term operational benefits compound most greatly. Verticals that could benefit from Optical LAN include:

- Manufacturing or Assembly Line
- Department of Defense military bases/posts
- Federal and municipal government agencies and entities
- Large hospitality facilities/hotels/resorts
- Higher and lower education campus networks
- Healthcare facilities/hospitals
- Large or small enterprise businesses
- Financial institutions
- Media companies
- Cruise/Naval ship communications
- Industrial/manufacturing plant networks
- Airports and stadiums.

Disruptively low total cost of ownership - Until recently, the high cost of a future-proof, fiber-to-the-desktop LAN architecture kept it out of reach for many organizations. However, today, capital expense related to Optical LAN equipment and infrastructure can be 40% less than the traditional active switched Ethernet approach. In addition, deploying a Optical LAN system can result in 50% to 70% savings in system operational expenses compared to a copper system due to less energy consumption, reduced HVAC and UPS cooling requirements, and lower monitoring and maintenance costs. This disruptively low total cost of ownership savings along with the many other benefits of the future-proof fiber infrastructure accounts for why Optical LAN is gaining traction in the market.

A few points of contention and a few realities to consider…

Contention – GPON has a higher cost per each additional "bit" compared to regular network.
Reality: Point to Multipoint is definitely less expensive than point-to-point Ethernet to deliver bits to each subscriber - How many 48 port GE to the desktop switches have you seen with a 48 Gig uplink? Try designing a cost effective network with a non-blocking architecture and price out the individual "bits" before and after.

Contention – GPON throughput compared to available copper products

Reality: Throughput supported at each port (100Mb or 1,000MB) is basically at wire speed therefore with little degradation if any. With dynamic bandwidth allocation or COS, we can give any user the bandwidth they need for the 10% of any given day they actually require it

Contention – Asymmetrical GPON bandwidth (2.4G/1.2G) versus copper (10G/10G) Lacks Power over Ethernet, requires more expensive units at each location, lacks centralized power, requires UPS for each location with PoE requirement like cameras and critical devices
Reality – GPON is 2.4G/1.2G, However XG-PON will support 10G-2.5G and NG-PON 10G-10G over the same single mode fiber; that said who has 10G/10G to the desktop or to the card? Many OLT GPON cards have two independent 10g traces. With two uplinks we have 20g going to each card.... non-blocking (2.5 X 8 ports = 20g). So how do you get this in a 48 port Cisco switch?

Contention – Lacks Power over Ethernet, requires more expensive units at each location
Reality – ONT's today support PoE and can be distributed throughout the deployment at a rate of 1 ONT per 8 desktops or more depending on throughput requirements. Consider this take a Cisco 48 port switch with POE. How far in cable feet (not distance across a building) can we go? 300 feet... that's it. This means I may have to strategically place my switch or have more than one EXPENSIVE Cisco boxes in the building to accommodate my users. With a GPON solution, we can put the POE where I need it at any distance up to 120K from the OLT (using GPON and or AE ONTs). Not every user needs POE so we can use non-POE ONTs for those Ethernet ports and save CAPEX spend.

Contention – Less secure as it broadcasts all data to all ports (shared medium)
Reality: GPON has encryption built in downstream and in XG-PON will add upstream encryption. GPON is inherently more secure than copper based Ethernet cables that can be effectively snooped by a variety of ways. Why are the NSA, CIA, FBI, Department of State, US Army and Air Force moving to Optical LAN and Secure GPON? Another point; set up a port mirror off of a splitter. Still concerned? OK, make it Secure GPON and still save money over a "secure" Cisco solution.

Contention – GPON runs only on single mode fiber optics cable (no multi-mode support)
Reality: Single Mode Fiber is actually a plus since single mode is future proofed regarding theoretical channel capacity. This contention highlights a major advantage of Single Mode Fiber since single mode does not have the distance limitations of multi-mode fiber and has been proven for carrier access throughout the world today! Second, there is not a price advantage to using Multi-Mode fiber over Single Mode fiber. GPON ONTs only require a single fiber to operate. The proven capacity of Single Mode fiber is 69 TERABYTES per second! Fujitsu has tested and achieved speeds of to 103 Terabits on Single Mode Fiber. For all

practical purposes *these highlighted lack of the same limitations as copper* mean that you have effective investment protection for your infrastructure for DECADES to come.

Contention – More complex to achieve redundancy and scalability
Reality: GPON is designed to meet Carrier grade reliability and availability and can be designed and configured for High Availability with complete redundancy end-to-end. Furthermore, when you are building a network with traditional LAN gear the highest level of redundancy you can get is by setting up a cross matrix backbone. Easy? No, you have to build a layer one infrastructure that can support it to ALL switching closets and the core. Expensive? You bet. We need to remind the customers that we build CARRIER class gear, not enterprise class.

Contention – Only 8 VLANs supported per port
Reality: Some GPON vendors can support over 4,000 VLANs on a single port using the S-LAN feature; alternatively most vendors support thousands of VLAN's per OLT.

Contention – Limited QoS and advanced Routing capabilities
Reality: GPON offers intrinsic attributes at the logical layer for facilitating QoS. Basic point-to-point Ethernet must be enhanced to allow service differentiation, thereby guaranteeing the requisite QoS for each service. For Ethernet-based services, service differentiation is achieved by classifying traffic flows based on service profile, using Ethernet Priority class (IEEE 802.1p bits) or IP DiffServ Code Point (DSCP), ingress Optical LAN, queuing and scheduling for traffic prioritization. In order to provide QoS in GPON, several mechanisms that are intrinsic in the PON realization are employed for classification of traffic into traffic classes; forwarding the traffic classes into GEM Ports and T-CONTs configured for QoS services. In addition to the intrinsic QoS embodied in the PON, Ethernet based QoS attributes can still be employed in the PON by the ONT and OLT.

Contention – Potential of Fiber cables damage during installations at each location
Reality – The potential does exist if the fiber is improperly handled; however, fiber is lighter, cheaper, allows for greater distances to be traversed; new high-bend, heavy duty fiber has been developed achieving greater throughput and easier deployment while meeting Green standards for new building construction.

Contention – Lacks unified industry standards
Reality: Very strict ITU standards exist beyond what exists for pure Ethernet Networks, i.e., G.984.4 OMCI standards are mandatory for management and control; however, SNMP for Ethernet is more of a defacto standard and not mandated.

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Networks, i.e., OMCI standards that are mandatory for OAM; however, SNMP for Ethernet is simply a suggestion and not mandated.

Contention – Distributed environment with low port density
Reality: Point to multi point architecture is much denser than point-to-point, vendors offer density that far surpasses Ethernet, case and point, roughly 2000 port of copper Ethernet requires 18 equipment cabinets, where as GPON would require about a half rack and support nearly 75,000 ports of Ethernet.

Contention – More suitable for Fiber to the Home (FTTH) than office environment.
Reality – why has it taken so long to bring fiber optic connectivity to the LAN? The rest of the world has evolved to Fiber optic connectivity for everything, from airplanes to access to mobile backhaul, don't you think it's time to bring Fiber to the LAN environment and get the tons of copper out of the closets!

FACTS that you should know about GPON

FACT: Definition of PON technology: "A PON takes advantage of wavelength division multiplexing (WDM), using one wavelength for downstream traffic and another for upstream traffic on a single Non-zero dispersion-shifted fiber (ITU-T G.652). BPON, EPON, GEPON, and GPON have the same basic wavelength plan and use the 1,490 nanometer (nm) wavelength for downstream traffic and 1310 nm wavelength for upstream traffic. 1550 nm is reserved for optional overlay services, typically RF (analog) video". PONs use Single Mode Fiber and do not consume power between the central chassis and the media converter, which can be up to 20KM or 12.4 miles from the distribution chassis.

FACT: Telecommunication companies such as Verizon (FIOS) have been implementing Fiber to the Home (FTTH) technology since the early 2000s. Verizon is far from alone in the use of xPON technology. According to Broadband Communities magazine, Summer 2012 edition there are "more than 800 companies" currently providing Fiber to the Home service just in the US. The same article opens with "FTTH has become the leading technology for next-generation communications networks worldwide. On *every* continent, telecom providers are building fiber optic networks to **replace legacy copper networks**". Today, FTTH accounts for some 80 million connected households with a bit more than 10% (8.5 Million) US based.
China is leading the implementations with a stated objective of 100 Million households connected by 2015.

FACT: FTTH is the ONLY Unlimited Broadband Technology" – in fact, one bundle of fiber cable not much thicker than a pencil can carry all of the world's current communication technology" so why would anyone consider investing another penny in copper cabling?

FACT: As with any technology, the standards evolve. Single mode bend-insensitive fiber has twice the tensile strength as CAT-6 (49 ft. lbs. vs. 28) and has a 20 KM distance limitation (ITU-T G.984) unlike copper at 300 feet and multimode fiber at 1200 feet.

FACT: Today, GPON is ITU-T G.984 based and offers 2.4Gb down, 1.2Gb up. Each PON can incorporate from 1:1 up to 1:64 splits and is dependent upon the committed and peak information rates. The next generation XG-PON or ITU-T987 is based on 10Gbps and offers 10GbE bi-directional, and up to 1:64 splits – no need to upgrade or replace the chassis; The generation to follow is NG-PON2 also known as offering 320Gbps, 100km reach, and ring reliability over the same single mode fiber.

FACT: Fiber vs. Copper; "Single mode fiber supports over 69 Tbps of throughput, making it a 'future proof' transport medium" – a single strand of *single mode fiber half the size of a human hair* carries as much data as a copper wire that is 4 inches thick.

FACT: Fiber Optic Cable has no Crosstalk, is not affected by EMI or EMP, and is non-conductive. The coverage area for a Passive Optical LAN is 483 square miles. This coverage and architecture difference limit the number of external connections – especially MetroE and other public Internet connections when working to interconnect buildings horizontally. Installations that comply with Hardened Carrier PDS per NSTISSI 7003 and SIPRNet/Classified LAN Protection methods are available. Additional NSA approved Encryption devices are available along with monitoring software. This far exceeds copper solutions. Additionally, Secure PON – Alarmed PDS with Thin Client & Cross Domain classifications can exist in the same physical plant. Armored Fiber provides further protection.

FACT: There are a number of solution providers in the xPON space today and more emerging as the customer base continues to evolve. Names such as Alcatel-Lucent, Calix, Ericsson, Hitachi, Huawei, Motorola, Tellabs, Zhone, and ZTE and a number of analyst firms such as Current Analysis, Infonetics and BBTrends track the GPON market and deployments.

FACT: OLT's today support in excess of 4000 VLANS per OLT. The choice of native VLANs or VLAN tagging is part of the system configuration and operating process. Some vendors have capabilities to support that same number of VLANS on a single port.

FACT: ONTs that are optimized for Enterprise LAN applications are available today, and include features such as intelligent PoE power management, LLDP-MED, 802.1X port based authentication, BPDU Blocking, Bridge Loop Detection, and more.