Fiber Optic Cabling and Passive Optical LAN for Education Market

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Low cost, converged, Optical LAN serves school facilities

Tellabs seeks to accelerate the deployment of ultra-high speed networks and broadband services to K-12, colleges, universities, campuses and affiliated communities. Tellabs' underlying strategy is to enable self-sustaining, next generation broadband networks that will provide affordable high-speed services to the educational facilities and their surrounding extended communities. It is Tellabs' opinion, and the position of this paper, that schools can deploy an extension of passive optical Local Area Network (LAN) solution to interconnect campus buildings, student housing, affiliated research facilities and other community members. By converging a passive Optical LAN and passive Fiber-to-the-Premises (FTTP) network architecture, schools can deploy an environmentally responsible fiber based access solution that solves their growing network challenges, while significantly cutting CapEx and OpEx, power consumption and reducing the cradle-to-grave environmental impact.

It is the position of this paper that schools, and their extended communities, can build a better business case for ultra-fast broadband access with lower cost fiber based Optical LANs that can be extended to affiliated community facilities with less investment and realize a sustainable business model that leverages both PON FTTP and PON Optical LAN as follows:

- Future proof with an all-fiber network infrastructure for both school LAN and affiliated facilities
- Converge services over fiber network with technology that enables lowest CapEx and lowest OpEx
- Build an open network that enables Ethernet, hosted/managed, cloud based and LAN architectures

Future proof all-fiber networks for schools and affiliated facilities

Inherent advantages of all-fiber networks – Ideally, an ultra-high speed network will be fiber based taking advantage of fiber's tremendous 101 Tbps bandwidth capacity[1]. Therefore, any outside plant or LAN construction project that provides end-to-end fiber connectivity is considered near "future proof" and can take advantage of the inherent benefits of fiber optics technologies, such as:

- Industry leading broadcast and aggregation capabilities with manageable split ratios
- Superior network reach
- Best choice for socially responsible "green" environmental tactics
- Graceful migration to future technologies
- Agnostic to technology, services and applications

[1] NEC April 2011 - http://www.newscientist.com/article/mg21028095.500-ultrafast-fibre-optics-set-new-speed-record.html

Schools can take advantage of today's ITU G.984 2.4 Gbps GPON Optical Distribution Network (ODN) split ratio, and superior reach, to cost effectively optimize traffic management based on bandwidth needs. That is, the vast majority of the LAN or access end-points requires relatively low bandwidth requirements (e.g. 1-10 Mbps)[2] and can be cost effectively placed on 1:64 ODN splitters. Compared to legacy copper based LAN that dedicates electronics, SFPs and fiber to every end-point, PON offers greater CapEx and OpEx savings. The schools can then deliver 100 Mbps to 1 Gbps services to their heavy bandwidth end-points by placing those ONTs on 1:8 or 1:4 splitters with appropriate Quality of Service (QoS) and Service Level Agreements (SLAs).

The record for distance traveled across a fiber optic network is 7000 km[3]. Today's PON technology has a theoretical reach of 60 km and is typically deployed in the 20-30 km range assuming Class B+ optics and 16 to 32 wide ODN split. This is what enables the schools to reach surrounding affiliated facilities with the same technology and equipment as recommended for LAN deployments.

From an environmental responsibility stand-point, PON has proven to have less resource depletion, greenhouse gas emissions, carbon footprint, and emitted toxins into the environment[4]. Other studies have shown that raw materials associated with copper consumes 100 to 200 times more natural resources than fiber optic glass raw materials[5]. Fiber also has longer lifespan (50+ years), thus resulting in better cradle-to-grave analysis.

Optical networks and PON provides graceful migration to future technologies, such as ITU G.987 10 Gbps GPON, with no wavelength conflict across the same ODN architecture that would be deployed today.

This PON architecture can be agnostic to the core routers, PBX, applications and end-point services (Figure 1) and provide the greatest flexibility whether services are IP/Ethernet centric (e.g. IPTV, VoIP) or analog centric (e.g. POTS, RF video). The network end-points stay the same, as well as the services and applications delivered across the PON network. Voice services can be delivered at the lowest price point with easy migration between analog POTS and VoIP options. Same holds true for video services, with PON providing lowest cost migration between RF Video, Satellite Video (e.g. DISH or DIRECTV), IP Video and Video conferencing options. This is also true for wireless networks and Wi-Fi Access Points (WAP) support.

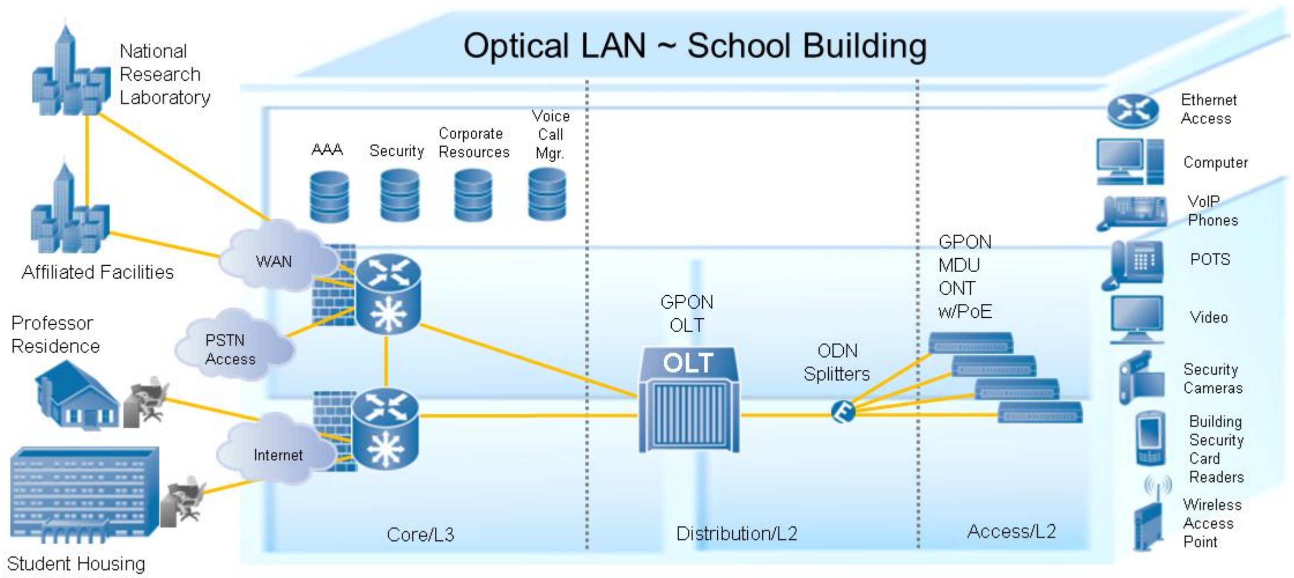

Figure 1: Optical LAN in a school campus architecture

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[2] March 2013 – Gartner Research — How Cloud, Mobile and Video Will Increase Enterprise Bandwidth Needs Through 2017 — ID Number: G00247697 — http://www.gartner.com/technology/research.jsp
[3] Bell Labs in Villarceaux, France, 155 channels, each carrying 100 Gbps over a 7000 km fiber, September 2009
[4] PricewaterhouseCoopers study, *Environmental Benefits of FTTH Deployments in the USA*, October 2008
[5] Michael Lettenmeier, Holger Rohn, Christa Liedtke, Friedrich Schmidt-Bleek, *How to Develop Eco-Innovative Products and Services and Improve their Material Footprint*, http://www.wupperinst.org/uploads/tx_wibeitrag/ws41.pdf, March 2010

Inherent advantages of all-fiber LAN networks – The benefit of fiber optics compared to copper has long been known by telecommunications service providers (i.e. FTTP versus xDSL[6]). Fiber optics has always realized significantly better reach, capacity, EMI tolerance, and fire safety when compared to copper based CATx. Over the past decade, fiber optics have benefited from improved durability, reduced bend radius, simplified connector systems, and lowered costs. During this same period, copper based CATx cabling has desperately tried to keep pace with bandwidth demands. CATx has gone through a series of major re-designs from CAT3 to CAT5 to CAT5e to CAT6A to CAT8. The problem being that every time CATx moves to the next generation, they do offer better capacity, but reach has stayed constant, EMI is still poor, diameters have increased, weights are heavier, bend radius has increased, connectors have become bulkier, and pricing has increased. We are now well past the tipping point where fiber surpasses copper for in-building structured LAN cabling and as the physical media for outside plant access networks.

Business case studies from early Optical LAN adopters show that deployment of Optical LAN can result in up to 50-70% less total cost of ownership, 80% less power, and 90% less space in comparison with legacy copper based LAN[7] deployments; SMF is a compelling piece of these positive business cases. Momentum continues to build for Optical LAN with leading industry organizations now embracing Optical LAN and its fiber optics based in-building structured cabling. For example, Leadership in Energy & Environmental Design (LEED) developed by the U.S. Green Building Council (USGBC) positively endorses environmental building guidelines understanding the tangible benefits and direct design savings with fiber optics for LAN structured cabling.[8]

A schools can use Optical LAN for their campus buildings and extend converged services to nearby communities that include school-related private facilities in the area (student housing, professors' residences, and private facilities associated with the schools such as local hotels and meeting facilities), as well as unaffiliated anchor institutions, entrepreneurial start-ups and other private businesses and residences. It can be expected that all of these entities will be very interested in deploying an all-fiber LAN that saves money, converts utility space into revenue generating square footage, lowers power [9]and decreases thermal environmental requirements. In fact, industry studies have shown that for every watt saved in IT/Telecommunications equipment, there is a cumulative power savings multiplier of 2x through-out the entire building. This 2x factors into account IT/Telecom equipment impact on power of AC-DC conversion, power distribution, power systems, ventilation and A/C cooling[10].

PON Optical LAN Introduction – Optical LAN extends broadband fiber connections directly to the local area network end users (Figure 2). It is the next generation enterprise technology that replaces traditional active Ethernet equipment and associated copper based wiring with PON equipment, implemented with near future proof single mode fiber, providing additional security and faster speeds.

[6] Fiber to the Home Council, 2011 *Fiber Primer - The Advantages of Optical Access*, http://s.ftthcouncil.org/files/bbp_marapr_primer_-_2011.pdf, October 2011
[7] Tellabs, Inc. - *A New Network Paradigm: Cutting Cost, Space and Energy Use* http://www.tellabs.com/resources/papers/tlab_olan-paradigm.pdf, June 2010
[8] Karen E. Thuermer, *Military Eyes Passive Optical Networks*, (Military Information Technology, MIT 2011 Volume: 15 Issue: 9 (October)) http://www.military-information-technology.com/mit-home/362-mit-2011-volume-15-issue-9-october/4907-military-eyes-passive-optical-networks.html
[9] *GPON in the Enterprise*, Sandia National Laboratories, Power Consumption Comparisons in Watts - Page 26, July 2009 http://www.internet2.edu/presentations/jt2009jul/20090720-brenkosh.pdf
[10] Verizon Energy Efficiency in the Network "*A Blueprint for Success*" August 2009

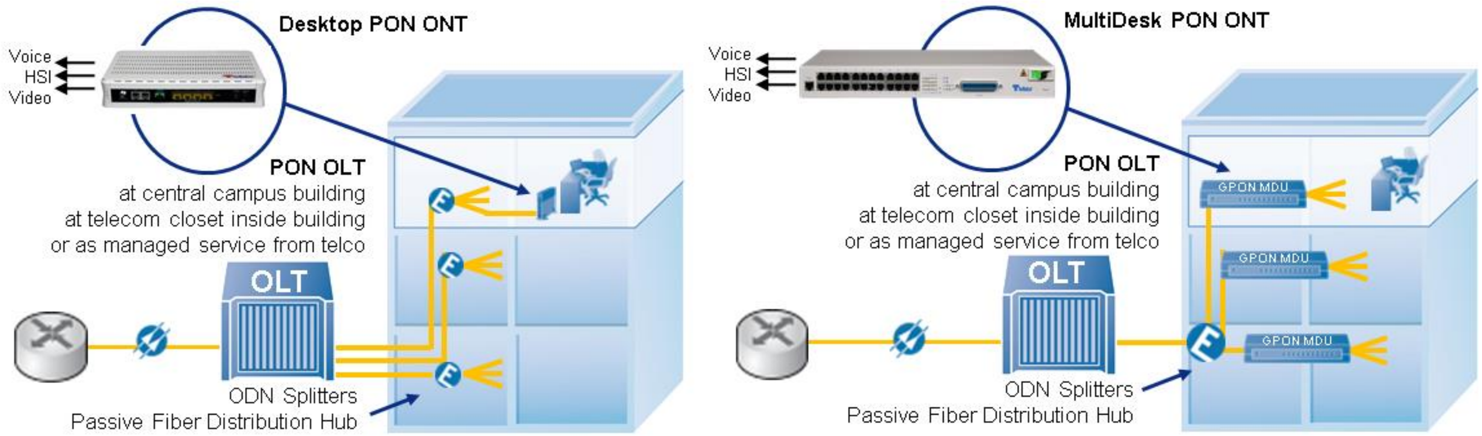

Figure 2: Optical LAN architecture for fiber to the Desktop ONT and fiber to MultiDesk ONT

Customer generated business cases have demonstrated significant CapEx savings and annual OpEx savings associated with less equipment to purchase up-front, install, power, cool, provision and maintain over time.

Converge Networks and Services over PON for lowest CapEx and lowest OpEx

Inherent advantages of PON – When telecommunications service providers first deployed PON, their objectives were:

- Extend network reach to 20-30 kilometers, where active Ethernet reach is limited to 100 meters
- Remove expensive mid-point electronics in the field – less electronics means lower CapEx
- Achieve lower OpEx with less equipment to maintain and lower power and power backup costs
- Simplified and centralized service delivery through carrier grade EMS and OSS

Today's PON accomplishes these goals by leveraging the inherent benefits of passive technologies with an all-fiber ODN that replaced aging copper infrastructure[11]. The passive nature of PON directly results in less expense, less power, less space and less maintenance. The flexibility to configure the ODN with 1:4, 1:8, 1:16, 1:32, 1:64 or even 1:128 split ratios enable network architects to design the network to balance bandwidth requirements with superior broadcast and aggregation capabilities. This architecture is optimized for both TDM voice and Voice over IP (e.g. SIP) and is also optimized for both IPTV, Satellite Video (e.g. DISH or DIRECTV) and RF Video. With all this in mind, PON was built from day one with carrier-class resiliency supporting both residential and business services delivery.

Converged FTTH and Optical LAN services – Not only can the PON Optical Line Terminals (OLT) support residential triple-play services, but other services like business Ethernet, cloud interconnection, mobile backhaul, Wi-Fi WAPs, high speed internet, IPTV and Optical LAN can all be ***simultaneously*** supported with the same PON technology (Figure 3). This enables schools to achieve an overall cost effective, end-to-end, business case when they roll-out services through-out their campus, including student housing, wireless access points and surrounding affiliated facilities (e.g. research facilities).

[11] *GPON in the Enterprise*, Sandia National Laboratories, GPON Advantages to the Enterprise - Page 25, July 2009 http://www.internet2.edu/presentations/jt2009jul/20090720-brenkosh.pdf

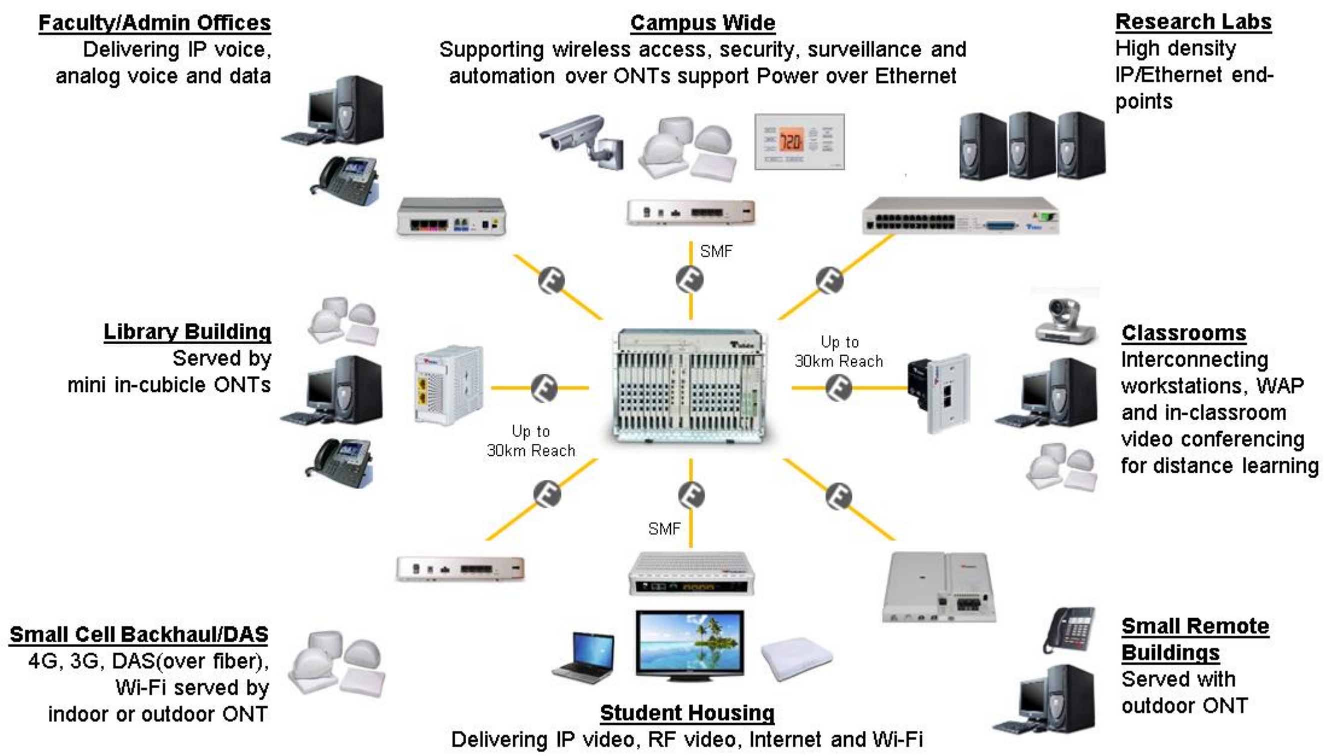

Figure 3: Converged PON network

Converged FTTH and Optical LAN architectures - With both PON FTTP and Optical LAN options available, schools can optimally determine the best way to extend their community network, such as the following scenarios (Figure 4).

1. The simplest architecture would be utilizing PON FTTP with an outdoor ONT. In this scenario the schools extends their network 20-30 km to the outside of target premises like local residences, student housing, and professors' residences. This can be supported in an "open network" model where all services are "force-forward" back to the up-stream telecommunications service provider.
2. Low cost PON FTTP indoor ONTs can be deployed and provisioned to send all traffic to a core BRAS router. This can be supported in an "open network" model where all services are "force-forward" back to the up-stream telecommunications service provider: i.e., multi-dwelling type housing, private facilities associated with the schools such as local hotels and meeting facilities.
3. Extending the schools network further, the choice can be made to use indoor MDU PON ONT and provision them as Optical LAN, so the entire campus participates in a LAN. These PON MDUs are equipped with 24 gigabit Ethernet ports that can leverage existing CATx wiring within the schools buildings. The OLT feeds these indoor PON MDU ONTs with fiber, grouping their ports into a peering scheme to mimic traditional enterprise LAN behavior. However, that OLT can be physically located and managed 20-30 km away from the ultimate end-point. The ODN splitters can be located anywhere between the OLT and ONT (e.g. schools facilities, unaffiliated anchor institutions, local research facilities, entrepreneurial start-ups and other private businesses).
4. The ultimate configuration will be delivering fiber all the way to the desktop or wall. Today, that fiber to the desktop and wall, may not exist, but will be the chosen LAN infrastructure media in the future for schools. Normal business cycles will present opportunities to upgrade to fiber where new buildings are being constructed, lease contracts have expired, a refresh of LAN equipment is required, or when existing copper CATx cable cannot meet the performance requirements.

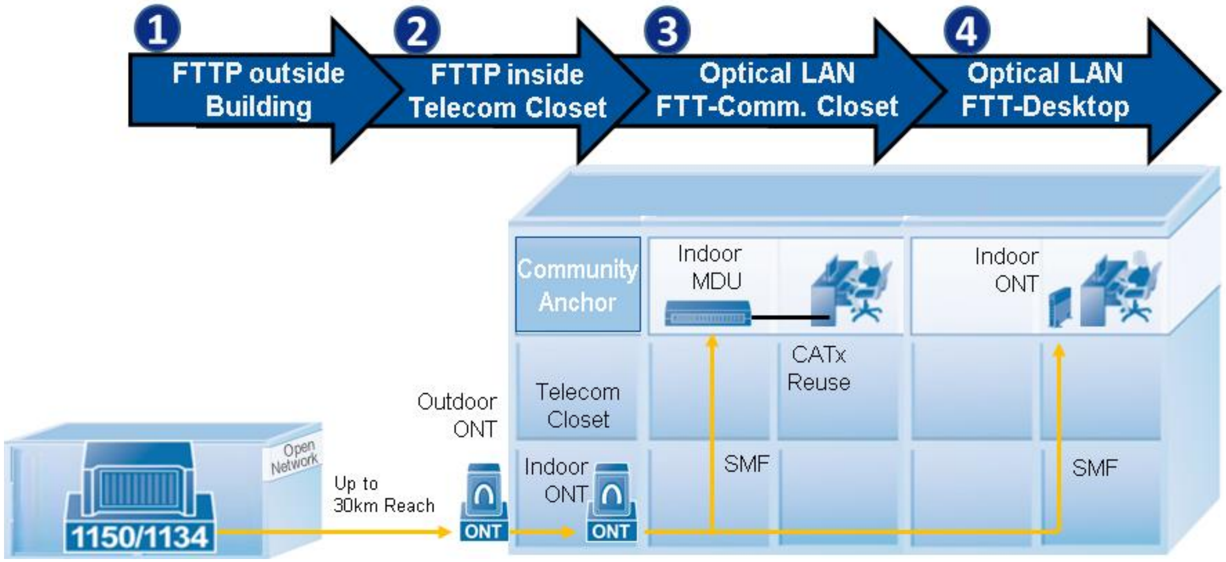

Figure 4: Optical LAN serving school facilities, community anchors, research labs & local businesses

Summary

The preceding paper outlined how schools and their extended communities can build lower cost fiber based Optical LANs, that can be extended to affiliated community facilities with less investment and a sustainable business model that leverages both PON FTTP and PON Optical LAN.

This strategy can provide the best business case for accelerating the deployment of ultra-high speed networks to K-12, colleges, universities, affiliated facilities and local communities. This strategy will result in self-sustaining, environmentally responsible, next generation broadband networks that will provide affordable high-speed services to the schools and their surrounding extended communities.

For more information, please contact your local Tellabs sales representative, local Tellabs sales office, at the phone numbers provided below or visit www.tellabs.com.

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