Debunking the Myths About Optical LAN

Tellabs responds to the Cisco-sponsored white paper: GPON vs. Gigabit Ethernet in Campus Networking

A recent Cisco-sponsored white paper, *GPON vs. Gigabit Ethernet in Campus Networking, by Nicholas J. Lippis III*, questions the relative value and benefits of gigabit passive optical network (GPON) solutions in federal and commercial business networks versus legacy copper-based, active Ethernet networks.

Lippis' claims about GPON equipment, networks and the security of fiber simply do not stand up under scrutiny.

Here are the top 10 myths about GPON in Lippis' paper — and the real facts about GPON.

Top 10 Myths … And The Real Facts

Myth #1: Though fiber-optic cable is difficult to tap without detection, GPON systems impose security risk.

Fact: Optical LAN provides powerful security measures at the physical layer, the data layer and at the user port to greatly reduce the potential for Denial of Service (DoS), redirects or other malicious attacks.

Fact: Tellabs Optical LAN provides Access Control Lists (ACLs), Broadcast Datagram Rate Limiting at each user device and strong authentication. Authentication based on 802.1x allows multiple devices per user port along with advanced intrusion detection — effectively locking down the physical port upon detection of an untrusted device. ACLs provide flexibility to statically and/or dynamically permit/deny datagrams based on Layer 2 (Ethernet) rules, Layer 3 (IP) rules, Layer 4 (TCP/UDP) rules and Network Access Control (NAC).

Fact: Fiber is superior to copper for security. Fiber has no crosstalk, is non-conductive and is not affected by electromagnetic interference (EMI), radio frequency interference (RFI) or electromagnetic pulse (EMP). Tellabs® All-SecureTM PON meets the federal government's most stringent Layer 1 security requirements for Secret IP Networks known as SIPRNet. The federal government has deployed Optical LAN in America's most secure networks, using alarmed secure passive optical network (SPON) integrated with alarmed fiber carrier protective distribution system (PDS).

Myth #2: GPON system is based on a two-tier fiber optic network where all traffic travels to a core switch. Thus, GPON traffic experiences poor performance.

Fact: Optical LAN architecture converges access, aggregation and distribution equipment by replacing those functions with passive optical splitters while delivering up to seven-nines of availability. Optical LAN converges VoIP unified communications networks with analog POTS, and multicast IP video (e.g., IPTV, surveillance and telepresence) with radio frequency (RF) video content on a single mode fiber (SMF) infrastructure.

Connectivity to the core remains the same, supporting Ethernet link aggregation (LAG), rapid spanning tree protocol (RSTP), multiple spanning tree protocol (MSTP), virtual router redundancy protocol/ Virtual Switching System (VRRP/VSS) and other standard protocols, which provide redundancy and resilience for the Optical LAN uplink interfaces. Legacy active Ethernet LAN architectures are almost always designed with a hierarchy of active equipment, sometimes adding 3, 4 and even 5 levels (e.g., on a campus). To achieve five-nines availability, all of those active nodes need to be equipped with multiple inter-connections, including dual physical connections to network endpoints — a highly impractical and cost-prohibitive design.

Fact: Optical LAN has supported integrated Ethernet bridging for more than 4 years, enabling local switching within the access, aggregation and distribution network for efficient, low-latency communication. This integrated Ethernet bridging support greatly reduces network loading at the distribution and core switch layers. Therefore, in a GPON system, all traffic does not travel to the core switch.

Fact: Optical LAN equipment manufacturers are investing in features and services necessary in enterprise solutions, including advanced security, quality of service, Power-over-Ethernet (PoE) both IEEE 802.3af PoE and IEEE 802.3at PoE+, power management, application monitoring and video enablement. In fact, Optical LAN provides superior security, superior quality of service (QoS) and superior PoE+ solutions compared with legacy Ethernet switch architectures. Most important to customers, Optical LAN's advanced features do not come with the heavy upgrade fees (e.g., right-to-use fees, annual service support fees) that are typically imposed by incumbent Ethernet switch network manufacturers.

Myth #3: GPON systems power calculations are grossly understated. Based on Lippis' calculations, copper-based LANs consume nearly half as much power as GPON.

Fact: Lippis compared 2,500 Ethernet ports on a Cisco solution to 10,000 Ethernet ports on a Motorola optical LAN solution — not even close to an apples-to-apples comparison. Of course, each GPON vendor's solution provides unique results. However, a more accurate comparison would be based on a leading Optical LAN solution from Tellabs:

- 1 OLT chassis, populated with appropriate modules
- 2,500 Ethernet ports, consisting of 625 desktop 4-port ONTs.

In this comparison, the total (worst case) GPON power consumption is 5,150 watts, resulting in a 70% power savings compared with the Lippis 2,500 Ethernet ports Cisco solution. This significant energy savings validates Optical LAN solutions' inclusion in specifications on projects striving for Energy Star, LEED or STEP accreditation.

Optical LAN is a proven, energy-saving green technology. That's why architects, developers and building owners who are developing green buildings choose Optical LAN. Optical LAN fits into a green IT infrastructure.

Fact: Because Optical LAN eliminates a large percentage of LAN access switches, total energy consumption declines. Claims of "up to 80% power savings" compared to legacy Ethernet switch architectures have proven themselves in many Optical LAN business cases using real-world deployments globally. In these Optical LAN business cases, GPON vendors do include ONT power consumption in network models and claims. A true apples-to-apples comparison validates this claim.

Fact: GPON ONTs follow IEEE standards for both IEEE 802.3af PoE compliant (15.4 watts per port) and IEEE 802.3at PoE+ (25.6 watts per port). The ONTs provide PD management, monitoring and configuration using LLDP. This means the ONTs' PoE port can detect the actual power requirements of a PD and then adjust the power allocation for that PoE port. The ONTs provide reports on power consumption so that IT managers can adjust deployment configurations, such as manually configuring low-power modes for devices like wireless access points and IP phones.

Fact: Performance of industry-leading ONTs supports full line-rate operation, enabling users to burst to the maximum performance of the desktop network interface card (NIC). Support for integrated PoE and PoE+ has been available for some time, along with remote powering options that eliminate the need for local power or local battery backup at the ONT.

Fact: The latest GPON ONTs benefit from support of IEEE 802.3az Energy-Efficient Ethernet enhancements. Ethernet port power utilization reduction is accomplished in a following manner. Normally these data links consume energy constantly to keep the physical layer transmitters on all the time. With IEEE 802.3az Energy-Efficient Ethernet enhancements the port goes into a "sleep" mode when no data is being sent. This is done by sending a low-power-idle (LPI) indication signal for a specified time, so the transmit chips in the system can be turned off. LPI is sent periodically to refresh the sleep mode. When there is data to transmit, a normal idle signal is sent to wake the transmit system up before data is due to be sent. The data link is considered to be always operational, as the receive signal circuit remains active even when the transmit path is in sleep mode.

The Truth About Passive Optical Equipment

Optical Network Terminals
The optical network terminal (ONT) is a low-cost, low-power, optical-to-electrical terminal that contains intelligent processing for network segmentation, QoS, power management, authentication and security. The ONT is positioned in the access portion of the LAN as close to the IP/Ethernet end-point served as possible.

Optical Distribution Network Splitters
The optical distribution network (ODN) includes the fiber optic cabling and ODN splitters that provide the passive connectivity stretching out 18 miles (30km) between the centrally located optical line terminal (OLT) and ONT end-points.

ODN splitters provide great network design flexibility along with simplified adds/moves/changes during normal business reconfiguration. These passive devices contribute to significant power savings. In addition, Optical LAN solutions increase reliability through the elimination of multiple layers of active Ethernet switches.

Optical Line Terminal
The OLT operates like any standard Ethernet switch, although the aggregation capacity is nearly 20 times greater than traditional chassis-based switches. Common interfaces, protocols and operations make the migration from legacy Ethernet switch networks to next-generation Optical LAN solutions easy. The GPON encapsulation utilizes GPON Encapsulation Method (GEM), which is based on a long-standing Ethernet transport protocol called Generic Framing Procedure (GFP). This standard protocol provides the same function as 8B10B — the protocol used to map Ethernet frames onto a gigabit Ethernet (GbE) interface — mapping Ethernet frames onto a fiber medium but with much lower overhead.

Fact: Integrated Ethernet bridging and advanced virtual local area network (VLAN) functionality have been standard in GPON-based Optical LAN solutions for many years. The OLT operates as a standard enterprise Ethernet switch, providing Layer 2 switching and Layer 3/4 processing as part of the advanced security, authentication, QoS and other advanced services architecture.

Optical LAN OLTs can be equipped with non-blocking, wire-speed switching capacity, which provides better performance than traditional legacy active Ethernet switches. Measuring switching capacity apples to apples, in the same manner as Ethernet switch vendors, the industry-leading OLT provides nearly a terabit of switching within a single OLT.

Fact: The GPON network is not a Layer 2 broadcast domain, but rather a highly intelligent enterprise Ethernet switch with advanced capability for security, authentication and QoS. All Ethernet switching functions occur within the GPON network. Connectivity to the core switch remains the same and is only used where Layer 3 routing functions are necessary.

Fact: Traffic is not forced to flow from desktop to the core switch. Integrated Ethernet bridging enables optimal user-to-user communication without traversing outside of the GPON network.

Fact: Core Ethernet switch functionality is not mandatory for proper operation of the Optical LAN network, so it does not represent a potential network bottleneck. Optical LAN OLTs do support integrated Ethernet bridging, along with advanced security, authentication, QoS and other advanced IP services. With the OLT providing integrated bridging, it does provide local switching that offloads traffic and lowers bandwidth demands (and port interface demand) on the core Ethernet switch or edge router.

Fact: Optical LAN solutions integrate seamlessly with VoIP solutions, supporting PoE (both IEEE 802.3af PoE and IEEE 802.3at PoE+), link layer discovery protocol (LLDP), advanced VLAN (virtual local area network) methodologies (tagged, untagged, trunked and terminated), service segmentation, advanced security and advanced authentication, including Network Access Control (NAC).

Fact: Each endpoint or desktop does not require an ONT, as many deployments share the multiple Ethernet port ONTs with multiple user locations. This approach optimizes the network architecture, lowers cost and reduces overall energy consumption significantly.

Fact: Bandwidth is shared per splitter in the same manner as bandwidth is shared within a workgroup switch. The concept and result are the same; only the method is different. The GPON interface utilizes advanced bandwidth management functionality to ensure each user receives bandwidth and QoS per the assigned profile within the Optical LAN network. GPON provides efficient bandwidth management on a more granular port-by-port level with increased efficient utilization of oversubscription. Most active Ethernet architected networks use a 24:1 or 48:1 oversubscription rate. However, a GPON solution oversubscription is typically closer to a 12:1 to 20:1.

Fact: Optical LAN ONTs have supported both IEEE 802.3af PoE and IEEE 802.3at PoE+ for several years. This includes the support of advanced power management, monitoring, configuration and control of powered devices (PD) and access points through LLDP.

Fact: Many ONTs are powered directly from the communication closet or zone distribution point, thus eliminating the need for local power or local battery backup. This deployment architecture is becoming typical in both federal government agencies and commercial enterprise markets.

Fact: The downstream path is encrypted, but the upstream path is not due to the inherent secure nature of the upstream communications. The OLT controls all ONTs' upstream transmissions. Today, there is no way for intruders to tap, bridge or reflect fiber optical transmission and the GPON protocol without breaking stateful (and monitored, alarmed) communications between OLT and subtended ONTs.

Fact: GPON does not broadcast data to all users. Rather, individual flows are mapped onto logical GEM ports to each ONT, which are individually encrypted using AES-128 methods. Like traditional Ethernet switch networks, a user cannot gain access to other users' data streams.

Myth #4: The fiber optic cable infrastructure has higher costs than copper.

Fact: Single-mode fiber infrastructure solutions cost 25% to 50% less than copper. These savings have been realized in many Optical LAN deployments. Cost savings are spread across components, materials and labor. Furthermore, when considering the impact of reductions in power, space, materials and weight on the building structure, the cost savings carries through an entire building construction project, as demonstrated in the following example:

- **GPON technology** — Reduced power, less weight, eliminated telecommunication closets and/or intermediate distribution frames (IDF)
- **SMF LAN** — Less weight, less duct volume, eliminated telecom/IDF closets, reduction in flammable material
- **Reduced HVAC requirements** — Due to much lower cooling and ventilation needs of GPON technology
- **Reduction in fire suppression systems** — Due to reductions in above-ceiling and in-wall flammable materials
- **Reduced concrete and structural components** — Due to eliminated telecom/IDF closets, reduced space and less weight.

Fact: A common complaint among network owners is the constant "network refresh" requirement that comes with legacy Ethernet switch networks. Not only does the equipment need refreshing and even replacement on a regular basis, the copper cabling infrastructure often does also. A network owner who installs expensive CAT6A cabling today is likely to pull it out and replace it with CAT8 in 5 to 10 years. Installing a single-mode fiber LAN today will save 25% to 50%, with minimal changes due to expansion and no need for a complete cable overhaul for at least 30 years.

Fact: Optical LAN utilizes SMF to the endpoint served (such as a cubicle, office, conference room, environmental control location, wireless access point, building automation, etc.), then converts back to a standard gigabit Ethernet interface via RJ-45. Therefore, optical NICs are not needed; instead, short category-rated patch cords connect the ONT and the endpoint device(s).

Fact: The PON optical budget typically is never a factor in enterprise network design, as standard GPON technology provides for 28dB of optical budget, enough to run the fiber up to 18 miles (30km). Even in a campus network design, one centrally located OLT can serve all the IP/Ethernet endpoints within an 18-mile radius (e.g., to serve remote buildings, maintenance workshops, security offices, housing, wireless access points, monitoring, video surveillance, security and building automation).

Fact: SMF is very easy to test and verify for correct installation in an Optical LAN. According to ANSI/TIA cabling standards, the SMF requires only one measurable metric in order to verify a proper installation, and that is the channel attenuation/loss. This is obtained by the use of a simple power meter and light source reading. According to industry standards, OTDR (optical time domain reflectometer) readings are recommended only for outside plant or when troubleshooting problems (Tier 2 testing).

Myth #5: GPON is less reliable than legacy copper-based active Ethernet switched networks.

Fact: A single OLT connected by a single fiber to a single ONT can achieve five-nines availability and reliability due to the carrier-class nature of the equipment. To configure an Active Ethernet user for five-nines availability requires fully meshed connections between 2 core/aggregation routers and 2 access switches with 2 NIC cards installed in the computer. All of these components drive the cost of such a configuration skyward.

Fact: Recent Type-B PON protection has enabled Optical LAN to achieve greater than seven-nines (99.99999%) availability, which means only about 3 seconds of unplanned downtime per port, per year. Legacy active Ethernet solutions cannot match that availability level. Type-B PON is a standards-based means of providing OLT redundancy and fiber-route diversity down to 2:x ODN splitter. Basically, a 2:x ODN splitter provides two paths back to a two geographically dispersed OLTs, or two separate GPON service modules within a single OLT.

Fact: PON enjoys a 10-year history of bringing carrier-class five-nines availability standardized telecommunications equipment that optimizes management and troubleshooting in the most demanding of environments (e.g., lifeline POTS, 911 emergency voice calls and Super Bowl Sunday video delivery).

Myth #6: GPON system hub-spoke design lacks design flexibility and GPON does not scale.

Fact: The design of the optical distribution network (ODN) for Optical LAN offers engineers and architects many choices. If financial constraints are not tight and the goal is pseudo point-to-point network architecture, then ODN splitters can be located in the data center room that houses the OLT. If costs are a concern and fiber conservation in risers and raceways is needed, the ODN splitter can be distributed closer to the endpoints served, which drastically reduces the quantity of fiber throughout the building. End-to-end campus network designers can use this ODN splitter placement logic as well.

Fact: All services transported over the Optical LAN network can be differentiated, and proper QoS assigned, for the greatest reliability and availability. For example, most ONTs can support up to 8 VLANs per port with each service provisioned with hard QoS (802.1p bit marking, Differentiated Services Code Point (DSCP) mapping, per service committed information rate, excess information rate, maximum burst size, which is far more capable than a legacy active Ethernet solution.

Fact: GPON is an ideal protocol for both real-time and best-effort traffic times. GPON has transported lifeline POTS for 10 years with proven, tested and regulated five-nines availability. Furthermore, during this same period, GPON has carried IPTV and RF video to millions of households.

Fact: Optical LAN equipment can be positioned anywhere within a network, within its respective 30km reach. Therefore, no blind spots can exist within this PON network that could not be served by gigabit Ethernet endpoints. Ethernet switching has advanced from 10Mbps to 100Gbps, but the cabling infrastructure used by Ethernet switches has not. CAT and MMF standards have been in a constant state of revision, with CAT3 advancing to CAT8, and MMF OM1 upgrading to MMF OM4. Each technology refresh has come at great expense and waste of resources. The cable infrastructure for Optical LAN (SMF) has proven 100Tbps capacity, and will support future technologies, including DWDM.

Fact Check: When an active Ethernet network evolves from 1GbE to 10GbE to 40GbE to 100GbE, it often means a total replacement of equipment and copper cabling infrastructure. In evolving a passive Optical LAN network, successful migration is possible with little service impact. For example, 10GbE GPON standards enable simultaneous operation of 10GbE service and 2.4GbE GPON service on the same existing ODN fiber infrastructure. Furthermore, future WDM-PON will deliver 1GbE point-to-point active Ethernet, 10GbE point-to-point active Ethernet, 2.4GbE GPON and 10GbE GPON over today's SMF infrastructure. As recently as January 2013, Cisco announced that the new Cisco 3850 series switches would replace the 3750-X series, a product released less than 4 years earlier.

Myth #7: Though fiber-optic cable has near limitless bandwidth, GPON's bandwidth is limited and GPON network capacity is inferior.

Fact: Ethernet switching has advanced from 10 Mbps to 100 Gbps, but the cabling infrastructure used by Ethernet switches has not evolved. CAT and MMF standards are in a constant state of revision, with CAT3 advancing to CAT8 and MMF OM1 upgrading to MMF OM4. Each technology refresh comes at great expense and waste of resources as old copper cables are removed and replaced. The SMF cable infrastructure for Optical LAN has reached 100Tbps speeds and offers the potential to support future technologies, including dense wave division multiplexing (DWDM).

Fact: Optical LAN ONT throughput can be line rate 1Gbps measured at a single 10/100/1000 interface of the ONTs and managed by appropriate QoS.

Fact: The PON optical budget is not a factor in enterprise network design, as standard GPON technology provides for 28dB of optical budget, enough to run the fiber up to 18 miles (30km). Even in a campus network design, one centrally located OLT can serve all the IP/Ethernet endpoints within an 18-mile radius (e.g., remote buildings, maintenance workshops, security offices, housing, wireless access points, monitoring, video surveillance, security and automation).

Fact: The Optical LAN OLT provides backplane and switching capacity on par with Ethernet switch vendors. The industry-leading OLT provides nearly a terabit of switching within a single OLT.

Fact: The Optical LAN OLT supports multiple 10GbE interfaces inter-connected to the core switch.

Myth #8: GPON ONTs are cheap, dumb and unmanaged access devices.

Fact: GPON ONTs are managed via a complete, easy-to-use graphical user interface (GUI). GPON ONTs are low-cost, low-power, optical-to-electrical terminals. They run a full operating system, and contain intelligent processing for network segmentation, QoS, authentication, security and end-device PoE management, configuration, monitoring and control.

Fact: Fundamentally, PON technology strives to remove complexity at the farthest reaches of the network. That is why PON manufacturers design ONTs with no local access for local operation, administration, maintenance and provisioning. This design precludes the possibility of malicious intrusion at the ONT and directly results in PON's ability to lower operational costs year-over-year. Characterizing ONTs as "dumb" misrepresents these facts.

Myth #9: GPON has many single points of failure and thus redundancy options are not available.

Fact: PON provides redundancy options at the core router at all points along the network topology: at the OLT, at the ODN splitter and at the ONTs. Redundancy schemes for PON include optical switches, type-B PON redundancy (described below) and ONTs equipped with dual GPON network uplinks. Recent Type-B PON protection has enabled Optical LAN to achieve greater than seven-nines (99.99999%) availability, which means less than 3 seconds of unplanned downtime per port, per year. Legacy active Ethernet solutions cannot match that availability level.

Fact: For Type-B PON redundancy options, a 2:x PON ODN splitter provides protection, redundancy and splitting functions. Type-B PON is a standards-based means of providing OLT redundancy and fiber route diversity down to 2:x ODN splitter. Basically, a 2:x ODN splitter provides two paths back to a two geographically dispersed OLTs, or two separate GPON service modules within a single OLT. Type-B PON ODN splitters can be sourced in 2:4, 2:8, 2:16 or 2:32 split ratios depending on infrastructure design criteria.

Myth #10: GPON lacks troubleshooting tools.

Fact: GUI-based element management software manages Optical LAN equipment. This is a more efficient method of managing a LAN than using only a craft user interface (CUI) at all the diverse, geographically challenged equipment location within an active Ethernet LAN. PON equipment utilizes an element management system (EMS) for easy management and troubleshooting, including user-friendly fault management (i.e., alarms, diagnostics and troubleshooting), configuration management (i.e., provisioning and upgrades), automation management (i.e., OSS, backups and restorations), performance management (i.e., reporting), security management (i.e., user roles and access controls) and inventory management. If CUI is desired, then Optical LAN equipment can provide limited CUI functionality for the most common LAN system management tasks.

Fact: Active Ethernet solutions typically rely on operation, administration and maintenance (OA&M) protocols for remote troubleshooting, performance monitoring, connectivity and fault management. GPON solutions provide all the same OA&M functionality, but add "P" for provisioning functionality. Thus, instead of OA&M, GPON provides OAM&P. The PON EMS' ability to provide global adds/moves/changes to automate service activation is a clear advantage. Automated service activation is provided by means of the ONT auto-provisioning function that associates global profiles to the end-device unique bandwidth, QoS and security criteria. This promotes machine-to-machine activity and reduces human touch, which greatly reduces possibility of human error. Large businesses lose around 4% annual revenue due to network downtime, and human error is the biggest contributor responsible for 50% to 80% outages.

The Real Story About GPON

PON equipment suppliers are dedicated to serving customers in the government and enterprise markets. As tens of millions of dollars are invested in research and development, hundreds of engineers are focused on Optical LAN, delivering customized features and functionality to market.

PON technology has been deployed globally to more than 40 million residential and commercial users, providing high-speed data, voice and video services. In recent years, the U.S. government's Joint Interoperability Test Command (JITC) certified GPON technology for deployment in government agency networks, including high-availability assured services (ASLAN) networks. Only technically sound solutions qualify for such a level of success in today's ever-evolving and complex IT networks.

That's why the next generation of LAN solutions will be based on passive optical network technology. The speed, flexibility, low energy, more stable, better scalability, SMF advantage and cost savings associated with this technology offer significant, positive steps in the evolution of IT networks.

Glossary

ACLs: Access Control Lists
ANSI: American National Standards Institute
CAT: category, e.g. Category 5 or CAT5
CUI: craft user interface
DoS: Denial of Service
DSCP: Differentiated Services Code Point
DWDM: dense wave divisionl multiplexing
EMI: electromagnetic interference
EMP: electromagnetic pulse
FiOS: Fiber Optic Service
GbE: gigabit Ethernet
GEM: GPON Encapsulations Method
GFP: generic framing procedure
GPON: gigabit passive optical network
HVAC: heating, ventilating and air conditioning
IDF: intermediate distribution frame
IEEE: The Institute of Electrical and Electronics Engineers
IP: Internet Protocol
IPTV: Internet Protocol television
LAG: Ethernet link aggregation
LAN: local area network
LEED: Leadership in Energy and Environmental Design, a green building certification
LLDP: link layer discovery protocol
MMF: multi-mode fiber
MSTP: multiple spanning tree protocol
NAC: Network Access Control
NIC: network interface card
ODN: optical distribution network
ONT: optical network terminal
OTDR: optical time domain reflectometer
PD: powered devices
PDS: protective distribution system
PoE: Power-over-Ethernet
PoE+: Power-over-Ethernet plus
PON: passive optical networking
POTS: plain old telephone service
QoS: quality of service
RF: radio frequency
RFI: radio frequency interference
RSTP: rapid spanning tree protocol
SIPRNet: Secure Internet Protocol Router Network
SMF: single mode fiber
SPON: secure passive optical network
STEP: Sustainable Technology Environments Program
TCP: transmission control protocol
TIA: Telecommunications Industry Association
UDP: user datagram protocol
VLAN: virtual local area network
VoIP: Voice over Internet Protocol
VRRP/VSS: virtual router redundancy protocol/Virtual Switching System
WDM: wave division multiplexing

Next Step:

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

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