To support the more than 50 users and a variety of network devices at TIA headquarters, the PON was installed using a 72-port optical fiber distribution hub that administers the optical fiber cable from the OLT.

Deploying a Passive Optical Network in a Standards-Based Enterprise Environment

Craig Kegerise is a product manager for optical fiber solutions within TE Connectivity's Enterprise Networks. He has been with the company for 39 years and is currently responsible for optical fiber connectors and tooling, as well as the optical LAN solution. Craig has a Bachelor of Arts in mathematics from Gettysburg College and holds various optical fiber patents. He can be reached at craig.kegerise@te.com.

Once perceived as a niche application for highly secure government installations, passive optical networks (PONs) are now gaining traction in the premise enterprise environment as a means to move optical fiber closer to the end user while speeding network deployment, saving space and providing a greener, more sustainable infrastructure.

PONs are quickly making their way into a variety of high port-count environments, including hospitals, universities, campuses, hotels, casinos, high occupancy buildings (e.g., call centers), and multi-tenant units. More recently, PONs are being deployed in lower port-count environments due to the energy, space and maintenance savings. To showcase this upcoming technology in a standards-based deployment, the Telecommunications Industry Association (TIA®) recently implemented a PON at its headquarters in Arlington, Va.

PON Basics

Sometimes referred to as a passive optical LAN, a PON is a point-to-multipoint architecture that employs unpowered optical splitters to enable a single strand of singlemode optical fiber

by Craig Kegerise

to serve multiple users (or devices). A PON is comprised of an optical line terminal (OLT) in the data center or main equipment room (ER), optical network terminals (ONTs) at the end user or device locations and a passive cabling infrastructure of singlemode optical fibers that use splitter technology to “split” the single input path into multiple output paths. At the work area, an ONT terminates the singlemode optical fiber and converts the signal to one or more twisted-pair copper outputs to interface with Internet protocol (IP)-enabled devices, including voice over IP (VoIP) phones, computers, card readers, cameras or wireless access points (WAPs).

Because a PON is passive, no power is required from the data center to the work area, which can translate into an energy savings of up to 50 percent, depending on the installation. Passive splitters replace traditional active switches and come in a variety of options, including some that integrate cross-connect patching or zone-type splitting that can free up a significant amount of square footage within a facility. In fact, in a PON deployment, multiple buildings can be served by one main ER. The lightweight, smaller diameter singlemode optical fiber used to connect the PON components (i.e., OLT to ONT) also uses less cabling material and requires less pathway space and associated pathway materials such as cable tray and penetrations. This combination of energy, space and material savings has led to PONs being recognized as an environmentally-friendly technology.

In addition to reducing the amount of active equipment and associated power and cooling, space and material, PONs offer a fast deployment. It is typically easier to install a single optical fiber to the work area rather than multiple homerun cables from the telecommunications room (TR)—especially when using available plug-and-play components to distribute the singlemode optical fiber all the way from the OLT to the ONTs.

An Advanced, Green Option

TIA, responsible for developing network cabling performance standards, considered its options and strived to deploy an advanced, emerging technology. They also wanted to take advantage of some of the newest technologies their member companies could offer.

"As a standards organization, we are at the forefront of technology, and we realized the PON was one of the latest technologies to consider," said Tony Zarafshar, IT manager for TIA. "While typically deployed for larger businesses, we decided to go with a PON because it was a new, environmentally-friendly option that we were excited about."

In addition to deploying a PON, the Association wanted to take advantage of a fiber-to-the-desk (FTTD) solution without the need for optical fiber network interface cards (NICs) installed in end devices. Because the singlemode optical fiber of the PON is converted to copper at the ONT, typical copper-based NICs and other network end devices can easily connect to the network. "We weren't new to this type of technology since we had some FTTD at our old location. But with FTTD, we had to purchase fiber NICs for every server and computer," said Bisrat Bainesagn, senior network manager for TIA. "With the PON, we have four copper interfaces at each ONT and can now avoid that expense."

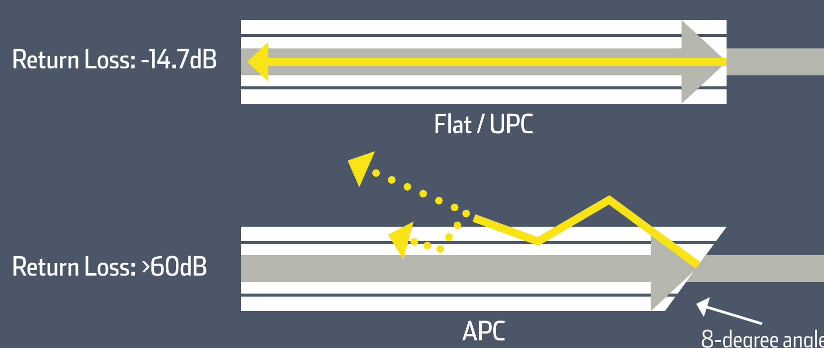
The project also demanded a solution that would allow a fast deployment due to time constraints. By using a plug-and-play PON solution, they were able to complete the entire installation in less than two weeks. "One of the great things about a plug-and-play PON solution is that you really don't need expert optical fiber termination craftsman on site," said Charlie Fox of Vector Resources, the design and installation contractor for the installation. "Everything is simply pulled from component to component and plugged in.

Why Singlemode and APC Connectors?

PONs use wave division multiplexing (WDM) technology, which combines multiple optical signals onto a single optical fiber strand by using different wavelengths of laser light. This enables bidirectional communications over one strand of optical fiber, using one wavelength for downstream transmission and another for upstream. WDM transmission requires singlemode optical fiber due to its higher bandwidth capacity. The smaller core of a singlemode optical fiber allows for the propagation of only one path of light, so distortion from overlapping light pulses is reduced. PON electronics are therefore singlemode optical fiber-based due to the optical fiber's higher bandwidth capacity and longer distance capabilities.

While the connection points in a PON can be a subscriber connector-ultra physical contact (SC-UPC) type simplex connector, it is recommended that angled physical contact (APC) connectors be deployed to reduce reflections. When a PON delivers radio frequency (RF) video signals, a third wavelength via WDM is used. This introduces back reflectance at connection points. RF systems are extremely sensitive to any back reflections from connectors—the reflected signal back into the downstream signal causes degradation of that signal.

The physical difference between APC and UPC connectors is the end face geometry. The APC ferrule end face radius is polished at an 8-degree angle, while UPC connectors are polished with no angle. When light is reflected at the flat connector interface of a UPC connector, it is reflected straight back at the source, increasing the return loss value. However, when the same signal passes through the APC connector, the angle causes the reflected light to be reflected into the cladding. The angle of the APC end face reduces back reflection in the 1500-nanometer and above wavelength range for proper transmission of injected RF video stream (analog). Additionally, future PON releases to support 10 Gb/s will utilize a higher wavelength of 1577, which is also subject to back reflections. Planning now for the future with APC connectors will avoid having to update connectors later.



The flat connector interface of a UPC connector reflects light back at the source, while the angle of the APC connector reflects the light into the cladding.

Another time saver is the fact that the comprehensive testing required with a typical installation is eliminated. Once the channel is up and running, the ONTs provide an immediate loss calculation on the optical fiber."

"When we first looked at PON, it wasn't about being green—it was more about taking advantage of a new technology and quickly installing a robust, scalable network that offered some key benefits," said Herb Congdon, associate vice president of technology and standards development for TIA. "In addition to singlemode optical fiber being the closest thing to a future proof media, the PON allowed us to reduce power consumption and raw materials with fewer electronics and just a few passive optical fiber runs rather than multiple copper runs."

In addition to the energy, material and space savings provided by the PON, TIA is also striving to reuse existing equipment and deploy applications that reduce paper consumption and waste. "To reuse existing equipment and maintain a standards-based installation, we also deployed a category 6 copper outlet to each work area, along with two singlemode optical fibers," said Congdon. "Throughout the entire planning process, we've

The OLT installed at TIA headquarters

taken sustainability into account. We eliminated paper-based documentation, and we will be deploying a variety of applications that further reduce paper consumption and waste, such as video conferencing and remote monitoring capabilities to reduce travel and associated greenhouse emissions."

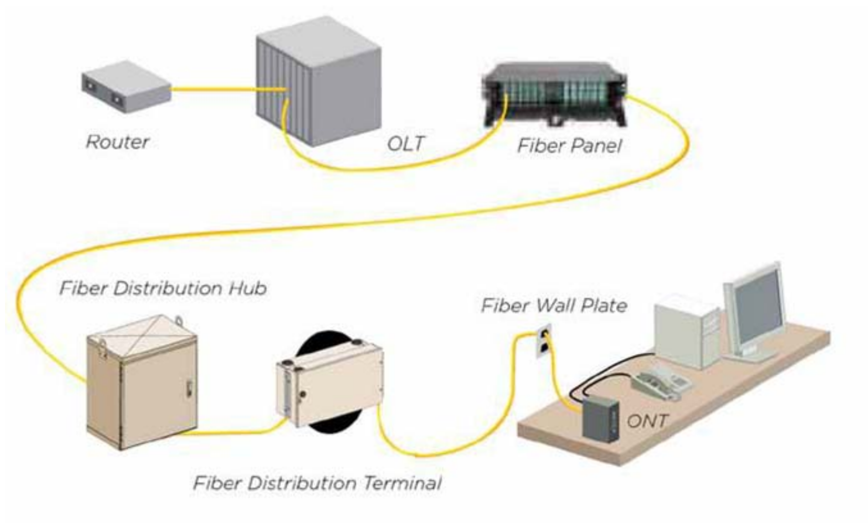
A Plug-and-Play Deployment

To support more than 50 users and a variety of network devices, the PON was installed using a 72-port optical fiber distribution hub that administers the optical fiber cable from the OLT. The hub uses splitters to distribute the optical fiber out to three compact consolidation points, and from there, to the ONTs at the workstation.

The OLT located in the main data center is a packet-based, high-bandwidth platform that supports incoming voice and broadband services. From there, singlemode optical fiber pre-terminated to SC angled physical contact (APC) connectors plug into cassettes housed in an optical fiber panel that serves as the interconnection point. The back of each cassette features a 12-fiber MPO adapter for simple plug-in of the pre-terminated 12-fiber feeder cable from the distribution hub. Within the distribution hub, the 12-fiber feeder cable is stored on a reel. Only the distance needed to connect back to the optical fiber panel is

The optical fiber distribution hub

The optical fiber distribution terminals that serve as the consolidation points closer to the work areas.



TIA headquarters features a PON design that takes up the least amount of floor space and requires the least amount of cable.

reeled off while the remaining cable slack is stored within the hub. As a result, there is no need to know exact cable lengths beforehand. The reel can hold up to 152 meters (m [500 feet (ft)]) of feeder cable, allowing the hub to be located virtually anywhere within the building.

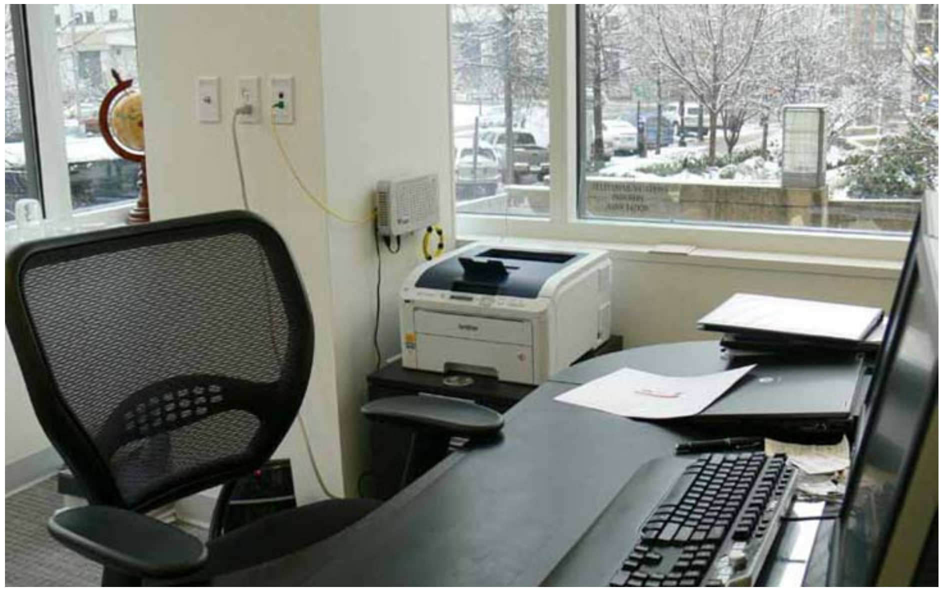
At the hub, the 12 single optical fibers of the feeder cable support nine splitter modules and three pass-through optical fibers. Only three of the optical fibers connect to splitter modules with nine remaining for pass-through distribution or future growth. The three optical splitters use advanced planar lightwave circuit (PLC) technology to split each of the three optical fibers into 32, for a total of 96 optical fibers. PLC technology offers higher split ratios, more precise splitting of the light and a compact size over traditional splitter technologies. In the hub, the 96 optical fibers cross connect back to 12-fiber MPO connectors for simple plug-in of the pre-terminated feeder cables from optical fiber distribution terminals that serve as consolidation points closer to the work area.

At TIA headquarters, three optical fiber distribution terminals are mounted to a cable tray close to the work areas they serve. Like the hub, the distribution terminals also feature built-in reels that hold either 12- or 24-fiber feeder cables. These cables are pulled back to the hub with the remaining stored at the distribution terminal on the reel. Within each distribution terminal, a localized patching field allows for single optical fiber cables to be distributed to work area outlets for connecting to the ONT.

While many PON installations only use one singlemode optical fiber to the outlet, as that is all that is actually required for the ONT, TIA deployed two singlemode optical fibers (i.e., duplex) to the outlet to reflect a traditional standards-based installation per TIA-568-C.

"The standards are designed to support a multi-vendor, multi-product, multi-application environment," said Congdon, "and while the current standard supports optical fiber to the desk, it specifies a duplex connection. We therefore deployed a duplex optical fiber to the outlet from the distribution terminals to ensure that we remained standards-based. That's the same reason we also included a category 6 copper connection at the work area—the standards specify two outlets. In our case, we have one copper and one duplex optical fiber connections at each work area outlet. Even though we may only use one optical fiber for connecting to the ONT, our standards-based installation allows us to support any application."

At each work area, the ITU-T G.984-compliant ONT features four copper interfaces that support 10/100/1000 BASE-T Ethernet for data and VoIP. The four ports can be used for connecting to a variety of devices, including laptops, personal computers, telephones, printers and other peripheral devices. In addition, 24-port ONTs were used for connecting to telephones in meeting areas and WAPS throughout the facility. The ONTs feature dynamic bandwidth allocation that allows for modification of bandwidth distribution across the four ports.



The ITU-T G.984-compliant ONTs mounted at each work area to support a variety of devices feature dynamic bandwidth allocation to provide a burst of bandwidth to any of the four ports as needed.

"One of the nice things about the ONT is that it can provide a burst of bandwidth to any of the ports as needed," said Zarafshar. "The ONTs also provide us with port-level management and monitoring so we can easily control the bandwidth that each user receives."

A Showcase for Technology

While other options exist for distributing singlemode optical fiber from the OLT to ONTs in a PON, the hub-and-terminal zone infrastructure installed at TIA headquarters took up the least amount of floor space, required the least amount of cable, and provided the greatest scalability and flexibility.

In addition to the easy installation that eliminated the need for field termination of the optical fiber, the new PON provides additional benefits associated with optical fiber, including resistance to electromagnetic and radiofrequency interference (EMI/RFI) and crosstalk, greater tensile strength and virtually unlimited bandwidth. With fewer electronics, the PON also offers reduced troubleshooting and maintenance costs in addition to the reduced power consumption.

From an extremely fast network deployment, to the energy, space, and material savings that meet the latest green initiatives, TIA's new network offers overall reduced lifecycle costs while joining the ranks of large government and big business facilities taking advantage of the latest in PON technology.

"While copper technology has done an excellent job of migrating and keeping up with bandwidth demands," said Congdon, "for a person like me who grew up as a 'fiber guy,' there is definitely a certain level of excitement to see a solution that effectively brings optical fiber to the desk." ■