Building the Foundation for the Next Wireless Boom
MAKE THE RIGHT CONNECTION WITH WAVETRAX

RUN YOUR FIBER CABLE THE TECT WAYS

The WaveTrax optical raceway system is designed for flexibility, durability and ease of installation. WaveTrax components adapt to your legacy architecture and are designed to suit any application in central offices, data centers or mobile switching centers. WaveTrax saves critical time, because you don't need tools for our snap-together system, and our competitive adapters allow for easy expansion on your legacy systems.

Telect engineers are available to custom configure your solution now.

CONTACT THE TECT TEAM
509.926.6000 // getinfo@telect.com // www.telect.com
6-9 Gigabit and MDUs: Capturing Generation Y
- Michael Sumitra, Strategic Solutions Marketing Manager, ADTRAN

12-14 The Art of STEALTH®
- STEALTH®

17 Filling the Gaps of the Ever-expanding Communications Network
- PREMIER

18-20 Communication Trends 2020
- BlueStream

22 AT&T’s Golden Boy

27-39 White Paper
Meeting the Unique Test Challenges of FTTx Deployment
- AFL

© 2017 KGP Logistics All rights reserved. The name PREMIER and the PREMIER logo are trademarks of KGP Logistics. All other marks are property of their respective owners.
Customers, Suppliers, Colleagues and Friends:

I hope your 2017 is off to a strong and healthy start.

With the pace of change today across our industry, there is no shortage of initiatives to work on, changes to initiate and investments to make. KGP Companies has grown and evolved to the company it is today through more than forty years of organic investment and growth, along with a collection of targeted acquisitions, while always anchored by the uncompromised core values embedded in the very essence of who we are by our founders.

This cherished journey has brought us to today, where KGP Companies is comprised of two companies; KGP Logistics and BlueStream. With large regional Distribution Centers and local staging facilities across the country, combined with the latest systems architecture, KGP Logistics is the industry leader in advanced supply chain solutions, value-added distribution, and product/software integration services. BlueStream is a premier solutions provider with a comprehensive suite of communication network management, engineering, and implementation services. Together, our business’ objective is to build, optimize, and transform our customer's networks. Since our acquisition of BlueStream, we have operated the businesses autonomously, within the framework of our values and the way we do business at KGP. At the same time, however, our industry and customers have also continued to evolve. Increasingly, we are engaged in opportunities that can benefit from, or require, the value both companies can deliver. This is true whether our customers are converting a central office or headend to a data center to enable a SDN deployment, building fiber networks, or expanding and densifying existing mobility networks through small cell or macro site deployments.

Recognizing that trend, in the near future you will see our company continue to enhance our go-to-market approach into a single, powerful brand that enables a value proposition focused on delivering advanced supply chain and distribution, solutions based professional network engineering and installation, and software integration services. We are excited about the formal merging of our capabilities, what it means to our customers and partners, and the solutions it will allow us to deliver. We are confident our recent preparation and investment will successfully lead us through this time of transformation. While we are by no means complete, nor will we ever be, we promise to continue our daily drive to challenge ourselves to think about things differently, to develop new relationships, create new capabilities, and ensure that we remain a relevant and reliable partner to our valued customers.

The approach to our continued evolution will continue to be deliberate, while opportunistic. Thank you for the opportunity to continue to move through this fascinating time of change with you. Our goal remains to be your true and trusted partner, and we deeply appreciate your continued trust and confidence in the KGP team. We look forward to working with you to make 2017 a successful year for your company.

Gratefully,

Trevor Putrah
President, KGP Companies
The epicenter of this transformation is the network—our passion. Our experts are rethinking the purpose, role and usage of networks to help our customers increase bandwidth, expand capacity, enhance efficiency, speed deployment and simplify migration.

From remote cell sites to massive sports arenas, from busy airports to state-of-the-art data centers—we provide the essential expertise and vital infrastructure your business needs to succeed.

The world’s most advanced networks rely on CommScope connectivity.

commScope.com

It’s the essence of the human experience.

How we communicate is evolving. Technology is reshaping the way we live, learn and thrive.

© 2016 CommScope, Inc. All rights reserved. AD-110497-EN
Multi-Dwelling Units (MDUs) consisting primarily of apartments, condos and mixed use multi-family housing, are experiencing occupancy rates at an all-time high. Providing premium broadband to the MDU market is a major opportunity for service providers, with over 80 million MDU households in the Americas, constituting over 35 percent of all homes in the United States. New multi-family housing grew by 10 percent in 2015, exceeding 390,000 (the greatest increase since 2000), and is expected to remain at high levels through the end of 2017.

Generation Y is now over 90 million strong with an annual buying power exceeding $600 billion. Millennials represent a major target market for service providers, as they currently comprise over half of all MDU residents. They are the first generation to have grown up with the internet and are therefore digital natives. According to a Goldman Sachs report, millennials are always connected: 80 percent have mobile phones, 75 percent are active on social media, and a growing number consume audio/video content online (38 percent watch TV online; over 44 percent download music/videos). This makes millennials a prime target for service providers with a focus on MDUs.

**The Case for Gigabit Broadband in MDUs**

Positioning Gigabit services in the MDU market requires not only convincing the tenant that they need higher-speed service, but also the building owner. For MDU owners, their primary interest lies with the economics of a Gigabit deployment. They want to see a return for their investment, such as increased property values on owned property and increased rental rates on leases, as well as a positive effect on occupancy levels with decreased tenant turnover.

So how does Gigabit broadband translate to MDU economics? A recent study by the Fiber to the Home (FTTH) Council showed that Gigabit service results in an 8 percent growth in apartment rent and a 2.8 percent increase in condo value (owned). So there’s a clear case for Gigabit in MDUs.

---

**Gigabit and MDUs: Capturing Generation Y**

Michael Sumitra
Strategic Solutions Marketing Manager, ADTRAN
Gigabit Architectures for MDUs

The unique nature of MDUs drives the need for a toolkit approach to delivering Gigabit broadband. Fiber connectivity is key, but service providers need to consider multiple Fiber-to-the-“x” (FTTx) architectures and technologies to deliver on the Gigabit promise.

- **Fiber-to-the-Living Unit (FTTLU) – A**: This architecture involves extending fiber directly to each living unit in the MDU, where it is then terminated by a single ONT or residential gateway. This is a complete future-proofed solution allowing upgrades to multi-gigabit speeds. However, this is a high-cost solution, requiring re-cabling with fiber, and causes tenant disruption.

- **FTTLU–B**: For low density garden-style apartments, an alternate option involves deploying nested GPON ONTs (up to 16-ports) with CAT5 cabling into each unit. The resident simply plugs their wireless router into a wall-jack to activate service. It also enables instant activation for the next-resident with no truck-rolls, elimination of vandalism (no equipment in the living unit), and increased ROI from each ONT.

- **Fiber-to-the-Floor (FTTF)**: In this architecture, fiber is extended to each floor, and living units are connected over copper (CAT3 or CAT5) or coax cabling, using a medium-density ONT (eight to 16 ports). This is a medium-cost solution and reduces tenant disruption.

- **Fiber-to-the-Building (FTTB)**: FTTB extends fiber to the basement or interior wall of building. Using a high-port count (24 to 48 ports) ONT or DPU, service providers can connect multiple living units cost-effectively over existing copper riser-bundles or coax.

In addition, there are a number of different technologies that can be used to deliver Gigabit services in the MDU market. The following matrix shows a comparison of these technologies and the FTTx architecture best suited for each technology:

<table>
<thead>
<tr>
<th>Technologies to Deliver Gigabit Services in the MDU Market</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deployment Model</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Physical Medium</strong></td>
</tr>
<tr>
<td><strong>Downstream Rates</strong></td>
</tr>
<tr>
<td><strong>Upstream rates</strong></td>
</tr>
</tbody>
</table>

*Throughput rates assume DTA and coax medium.

Generation Y is now over 90 million strong with an annual buying power exceeding $600 billion.
DEFINING THE FUTURE NETWORK

Broadband transforms communities, rebuilds urban centers, revitalizes schools, stimulates economic growth and delivers innovative residential and business services. ADTRAN is defining the future network with uniquely open and interoperable fiber-optic based access architectures that enable service providers to expand their addressable market and support the scale needed to unify Gigabit services across residential broadband, cloud connectivity and infrastructure backhaul applications.

Learn more at adtran.com/broadband
**App-Driven Services Delivery**

Tenant turnover is a key challenge that service providers must address with respect to broadband services in MDUs. The average apartment lease is 12-14 months, while the average payback period per subscriber is between 18-24 months, making serving an MDU subscriber a costly proposition. Service providers need to transition their business model from turning up individual subscribers to, Gigabit-enabling the living unit and enabling self-service activation.

Millennials have grown up in an instantaneous, on-demand economy where everything is an “app”. They want to be in control of their experience and they want the ability to choose the services they value. To succeed in capturing this generation, service providers must deploy highly programmable SD-Access networks, which enable network automation and service orchestration, and support extending self-service capabilities via a mobile app. For millennials, a self-service app allows them to select and activate services on-demand, eliminating truck rolls and delivering a user-driven customer experience.

**Universal Wi-Fi**

Wi-Fi access in MDUs is perhaps the most critical extension of broadband service delivery. For millennials, Wi-Fi is their primary means of accessing the Internet with smartphones, tablets, laptops and other devices. However, Wi-Fi in MDUs presents a major challenge for service providers. Signal bleed from Wi-Fi routers or residential gateways (RGs) in neighboring living units can cause interference and slow Internet connections. Wireless interference results in poor signal quality, slow network speeds and a poor customer experience. A next-generation wireless architecture is required for MDUs.

Adopting wireless RGs and APs with built-in radio resource management (RRF) is key to delivering Wi-Fi in MDUs. RRF is an enterprise-grade self-optimizing network (SON) technology that automatically selects the right Wi-Fi channel setting and transmit power of each RG or AP, to maximize coverage across the MDU, while eliminating interference from neighboring APs.

Seamless roaming is another requirement, as residents expect connectivity whether in the living units, hallways, or common areas, without having to login multiple times to access the network. Instead of deploying additional APs for coverage, utilizing the existing RGs and enabling an additional public SSID and L2 roaming between the RGs can be an effective solution. Seamless roaming can be provided for all residents, significantly reducing CAPEX.

**Summary**

The MDU market presents a great opportunity for service providers equipped to offer Gigabit services. It is important to remember that MDU owners and property managers see Gigabit broadband as a means to charge higher rent, higher occupancy and increased property values. Service providers must translate the benefits of Gigabit broadband into how it can improve business for the owner/management company. To succeed, service providers need to adopt a broadband toolkit approach that not only addresses the optimal deployment strategy for different MDU types, but also adopts a next-generation SDN network architecture service and enables flawless Wi-Fi. By doing so operators can offer increased service flexibility and innovations, vital for millenials’ lifestyles.
When every splice in your network is critical, why risk compromising your service levels at the final connection.

The new COYOTE® STP enclosure is the only option to consider for the final stage of FTTx deployment.

COYOTE® STP
(Service Termination Point)

- Small Scale and Cost Effective
- Flame retardant and UV stabilized materials
- Latch system allows quick entry and secure sealing
- Supports a wide range of cable profiles for above and below grade applications

For more information about PLP Coyote Products contact KGP Logistics at www.kgplogistics.com | 800-328-5142

440.461.5200
inquiries@preformed.com
www.preformed.com
The FiberChek probe builds on Viavi’s industry leading expertise in fiber inspection to deliver a single “all-in-one” handheld solution that every technician can rely on for all of today’s fiber inspection needs in a fully autonomous, handheld device. With built-in capabilities for image viewing, auto-focus, Pass/Fail analysis, storing/recalling results, the FiberChek probe completely automates inspection workflow to ensure fast and accurate performance. Whether used as on its own or connected (WiFi, Bluetooth, USB) to other devices, the FiberChek probe is the essential fiber tool for every technician.

2016 Cabling Installation & Maintenance Gold Innovators Award

For more information contact KGP Logistics at: 800-328-5142 or visit www.kgplogistics.com
There are thousands upon thousands of cellular antennas scattered across the landscape of this planet, from cell sites, to Small/Metro Cell, to DAS, encompassing Macro, Micro, Pico and so much more. The widespread deployment of communication equipment is as wide reaching as the connectivity that they provide consumers.

With the proliferation of in-building antenna systems and the need for pleasing aesthetics within these venues, design and concealment have become increasingly more necessary. Function still takes priority over form; however, companies have begun to develop concealment options with little impact on functionality, cost or speed of deployment. Concealment design and engineering has now stepped outside to larger scale antenna systems, stadiums, buildings, signs and posts, offering the functionality and coverage of a traditional cell tower, while retaining the character and aesthetics of the location.

The aptly named company, STEALTH® Concealment Solutions, Inc., has been at the forefront of concealment solutions for almost 25 years. STEALTH® created the country’s first ever RF-transparent antenna concealment system in 1992, and with it, the concept of concealment was born. The science behind their design is the use of the highest-grade radio-frequency (RF) transparent materials on the market, along with hours of design and testing to balance signal strength, structural integrity, and cost efficiency.
Hidden in Plain Sight

The primary challenge of delivering wireless service has, and will likely always be, delivering capacity and coverage in dense areas. The advancement of distributed antenna systems (DAS) throughout the early 2000s dramatically improved capacity and extended coverage into previously uncharted territories.

One such area has been the growth of DAS capabilities in sporting and entertainment venues. For most of the 21st century, the density of wireless devices used within entertainment venues led to a virtual traffic jam of data. Bringing DAS systems into these locations drastically enhanced the experience for event-goers and boosted the attendance and capabilities for the promoters. Building these systems, however, was not without its own set of challenges. First, antenna alignment, calibration and networking must serve its intended purpose. Second, stadiums and venues are designed to be aesthetically pleasing – and should remain that way. Concealment and antenna systems are paramount to creating an atmosphere where coverage and capacity operate together and go unnoticed.

Armed with an arsenal of options, STEALTH® covers the entire wireless industry with rooftop, tower, pole, DAS and custom concealment structures. When considering concealment options, STEALTH® must manage coverage of the hardware, public interaction, aesthetics, and most importantly, the ability to grow or change with time. In his article, ‘Insatiable Hunger Feeds DAS’, Trey Nemeth, Vice President of Operations for STEALTH®, points out that, “Forward thinking owners have already installed DAS to future proof their sites, but change comes fast to the wireless world. Any site more than two years old is probably already obsolete, and is not delivering the coverage in which owners expected.” In this regard Nemeth points out that, “Upgrading means bringing in more antennas; and that means multiplied aesthetic challenges.”

STEALTH® continues to remain at the forefront of concealment solutions, a paradigm shift has occurred, but they’re ready for it. The concept of concealment has changed from providing the smallest possible concealment structure to minimize the total footprint to larger structures with a pleasing aesthetic design, giving the engineers room to grow with less impact on the look of the venue or the cost of concealment.
Keeping the “Metro” in Metro Cell

Buildings are tall. Cities are full of people. This is not earth shattering news. It’s quite remedial in fact, but these simple facts point to the struggle of wireless connectivity and cell tower usage in metropolitan areas.

Upon close inspection we see that the issues with connectivity in crowded metro areas goes much deeper than sight lines and cell phones. Internet of Things (IoT) devices, Wi-Fi over LAN, and signal interference create a symphony of chaos within the world around us. With all of these challenges, careful planning and design of Small/Metro Cell systems allow for capacity and coverage that cut through the clutter below the towering skyline of the city. Placement is a key element to success, but managing virtual noise by adding visual clutter is not a viable option.

There are two popular tactics for concealment in metropolitan areas. One is to conceal or hide the antenna systems completely, using high-grade radio-frequency (RF) transparent materials. The other option is to camouflage. That is, to integrate the antenna design into objects that appear to be normal everyday pieces of the landscape.

Conceal

Innovations like StealthSkin™ and RadomeFlex™ have allowed STEALTH® to integrate and hide communications components in plain sight behind signs, billboards, steeples, silos and more. Through careful design and engineering these concealments not only work at an optimal level, but they also provide room for future growth.

Camouflage

Sight lines and the directional layout of antennas are essential to effective coverage in a Small Cell/ Metro Cell system. To allow for greater coverage and more control of antenna placement, incorporating the antennas into the landscape of a given area can be the key. Small Cell antennas are often inconspicuously installed on existing right-of-way street signs, telephone poles, or streetlights. Where concealment uses the architecture to hide communication hardware, camouflage simply incorporates the hardware into the landscape that we see.

Pittsburgh is the “Steel City,” known for being raw and hard working. Seattle is the “Emerald City”, with lush green landscapes and clean air. New York City is the “City that Never Sleeps”. Tourism boards spend extensive time and funding building the “brand” of metropolitan areas. Nobody wants to be known as the “City of Cell Towers”.

Concealment is the solution to aesthetically deploy Metro Cell solutions in an area without muddying up a landscape with plain gray boxes.
Our success is invisible. For 25 years we’ve continued to lead the industry in innovation with superior concealment materials! We do more concealment than anyone and we do it best. No matter the site, no matter the antenna, we have a hidden solution.

ROOFTOPS, SILOS, STEEPLES, CROSSSES, SMALL CELL, DAS, TREES, POLES & MUCH MORE
• 30+ years sourcing carrier quality products
• Average 20+ years’ experience with Product Managers
• Products backed by a 5 year warranty
• 25 year warranty on structured wiring system products
• 80%+ Domestic suppliers
• TL 9000 Certified Quality Management Systems
• Sourced under ISO 9001:2008 Registered
• RUS approved

www.DependonPREMIER.com
Filling the Gaps of the Ever-expanding Communications Network

PREMIER has been involved with the communications industry a while. Not since the days of smoke signals and drums, but we have been there to see many firsts. The first Fiber-to-the-Home (FTTH) deployment; the expansion of the cellular network and its growth from 1G to 4G with 5G on the horizon; the invention of the World Wide Web; the advent of ADSL and VDSL, VoIP; and now we are seeing G.fast, GPON, MoCA, among others. We have seen speeds go from 2400 bps to 10 Gbps.

Through all of these advances, plus the many speed and bandwidth improvements, PREMIER has played a part in providing quality cost effective products to Carriers for use in their networks.

In essence, every network, from the smoke signals of the Stone Age to today’s billions of connected devices, consists of three primary components – a transmitter, a receiver and a transmitting medium (the channel that carries the signal). But a network is not that simple. There are many supporting products needed to support a network. That is where PREMIER comes in.

Network operators don’t have the capacity to worry about every item in the network. PREMIER has been there for over 33 years reducing that list of worries. Our purpose has been to remove the pain points for our customers; starting with reliability, quality, cost reduction and improved availability.

PREMIER was born from within a carrier, so when it comes to carrier grade, we have lived it. We run first article inspection tests, audit factories and suppliers, drive field trials, reject off-quality samples, and investigate corrective action requests. We were TL9000 certified before most knew what it was. Quality and reliability are who we are. It is in our DNA.

Today’s networks evolve more quickly with every year. Legacy products and solutions have been reduced to a smaller scope, while new technologies and supporting product needs are emerging. As the product landscape shifts, PREMIER continues to be a reliable source for high quality, cost effective products. New networks, new technologies and cutting edge components are demanding more of the network engineer’s time and attention. Let PREMIER be your resource to worry about the needed but less critical components.

Tell us what pains you have. Where do you see holes in the product supply landscape? What components do you want to take off that worry list? Help us help you

Allow PREMIER to do what we do best: manage the specifications and standards process; ensure quality is front and center in the product development; handle the prototyping and production phase to keep project timelines on track; provide the on-going technical and application support as well as the customer service to make getting the products you need as painless as possible.

Bottom line: we’ll make sure your needs are met. Depend on PREMIER.
Communication Trends 2020

In a recent article, Christopher Surdak, JD, a global subject matter expert in Analytics, Governance and eDiscovery with HP Software studied hundreds of predictions from telecommunications industry observers, and distilled them into a list of six external factors that are predicted to drive the most change in telecommunications by the year 2020. His list includes:

1. Integration–The Content Contest

Being connected continues to become cheaper and cheaper for consumers, driven by falling costs of providing the service, as well as continued competition. As a result, connectivity is capturing an ever-smaller proportion of the information value chain, while content, service, and product deliverers capture ever-more. By 2020, it is likely that one or more major telecom companies will be acquired by a content company.

A mere nine months after the initial publication of this article, we see the once hard lines between carriers, content producers and manufacturers blend. AT&T is a telecommunications company, an ISP, a security company and now, with DirecTV, a satellite broadcasting company.

Google is an ISP, a fiber company, a content provider (YouTube), a ubiquitous OS (Android), a smartphone manufacturer (Pixel), a smart home hub (Google Home), and on and on. Look at Verizon and Amazon for similar examples of convergence and the reformulation of how and where to compete in a highly connected world.

2. IoT–The Traffic Explosion

The next major trend that Surdak predicts will impact telecommunications is the explosion of connected devices. This internet of things, or Thingification, will add billions if not trillions of new connected data sources globally by 2020.

His prediction is that the upswing of all of these devices will be an astronomical growth in data volumes; we will quickly push through exabyte volumes and enter the world of zettabytes per year.

3. Mobility–The Great Wireless Migration

Global growth of mobile connectivity is far outpacing hardline connectivity. This makes sense, as most growth is occurring in the developing world and amongst poorer populations. Such consumers may not even own a home, let alone a FiOS connection. For these people, mobile is cheaper, more convenient, and more useful, even when landline connectivity is an option.
4. Saturation–The Search For Growth

As they retire, boomers will enter retirement communities and assisted living facilities which are fully digitized in order to be as efficient as possible. Older Americans will be forced into using these technologies by the world around them and will likely consume vastly more bandwidth than they, or their carriers, ever imagined. As this occurs, the last remaining percentages of market penetration will be achieved, and the market will be thoroughly saturated.

5. Security–Threats to the Network

As custodians of the networks, carriers play a pivotal role in fighting the new threats that are emerging. Customers will begin to expect, then demand, more proactive protection from the entire internet value chain, and carriers will be expected to support these expectations with a range of technical and operational innovations. The desire for greater security may be a boon for carriers, if they embrace the need. Remember number two on this list? Imagine a fully connected Smart Home without adequate security measures to ensure privacy or defend against hackers.

6. Ascension–Skynet Finally Gets Real

Finally, Surdak predicts that Skynet 2.0 is about to reappear. These space, balloon, or drone-based systems will provide high-quality broadband access to anywhere and everywhere in the world, they’ll do it affordably, and they’ll likely start arriving around 2020. And this time, they’ll be wildly successful.

Of course, one of the common threads among all of Surdak’s prediction, even the last sci-fi’ish one, is that somehow all of these trends must be supported by an infrastructure services company.
As content devours bandwidth, more must be supplied.

The most practical potential of IoT at the moment may well be connected home technology. Implementing home automation, security and communications is a real business, and may well be a significant part of an industry that is projected to be worth over $78 billion by 2022.

Globally, the migration to wireless and complete market saturation is merely the culmination of the inevitable march of progress and the adoption of technology that has rapidly become efficient, effective and cheap. And as market demand and acceptance becomes universal, so too will the continual need for delivery infrastructure.

While meeting all of the infrastructure demands of today, BlueStream continues to keep an eye on the needs of the future. Through an ever-expanding list of infrastructure deployment services, expertise and strategic partnerships, BlueStream will remain a premier provider of infrastructure solutions to carriers, OEMs and consumers alike.

This statistic highlights a number of items:

1. The number of smartphones and other connected devices able to complete transactions continues to increase;
2. People are becoming more and more comfortable conducting transactions on their mobile devices;
3. The importance of device and information security cannot be overstated as the depth and breadth of connectivity continuously expands.

Sources:

Densification of the network to meet the growing data demands are resulting in a multitude of wireless and wireline access technologies being deployed. BlueStream’s comprehensive offerings are well suited to support the resulting heterogeneous environment including edge networks.

IOT and Broadband is fueling the load on the network and newer transport and backhaul technologies hold the key to providing ubiquitous connectivity across the network. BlueStream is well positioned to support these needs with solutions including Fiber and Microwave offerings.

BlueStream core services offerings include hardware-optimized platforms or cloud-native virtualized network functions to support NFV evolution. Big Data Analytics and in-house IT/IP expertise brings value added business intelligence.
AT&T’s Golden Boy

The official name of the image commissioned by Western Electric, to be fashioned into a statue, was originally The Genius of Electricity. Commissioned in 1914, it was sculpted by Evelyn Beatrice Longman. The work was completed in 1916 and hoisted to the roof of AT&T Corporate Headquarters at 195 Broadway in the Lower Manhattan area of New York City. It weighs over 16 tons and is 24 feet in height with wings that extend nine feet from the body. It is cast in bronze and covered with over 40,000 pieces of gold leaf.

The Genius of Electricity appeared on the cover of the Bell System telephone directories for about a decade beginning in the early 1930s and became a very well-known symbol for the Bell System and its affiliated companies.

In the mid-1930s, AT&T changed the name of the statue (and the image) to The Spirit of Telecommunications. It continued to stand atop the 195 Broadway building until 1984. That year marked the opening of a new postmodern headquarters building for AT&T located at 550 Madison Avenue in midtown Manhattan. The roof of the new building was a sloping inverted V with a notch in the center. There was no place for the statue on the roof, but AT&T created a seven-story lobby that contained a specific alcove to host its well-known statue and “Golden Boy” took up residence there.

By coincidence, 1984 also marked the end of the Bell System. During the 1990s, the telecommunications industry experienced significant changes. The New York City headquarters building was sold in 1992 to Sony and the company relocated its headquarters across the Hudson River and forty miles west to a 140-acre campus in Basking Ridge, New Jersey.

Golden Boy made the trip and was installed in front of the main entrance of the building in 1992. There it stood for a decade until 2002, when AT&T sold its Basking Ridge property and moved down the road to Bedminster Township, which had been the headquarters of the AT&T Long Lines division and home to the company’s national network operations center. Once again, Golden Boy also made the move.

In 2009, AT&T moved Golden Boy to the company’s new and current global headquarters in Dallas, Texas, where it stands in the Dallas lobby of the Whitacre Tower at 208 S. Akard Street.
Just plug it in.
No pairing.
Now, go play.

A Comtrend to Comtrend Innovation
For more information please visit http://us.comtrend.com/wifixtend/
Join us at the show!

Booth #206

Visit booth #206 at FTTH Fiber Connect 2017 to learn more about KGP Logistics supply chain capabilities for all fiber deployments.
Fiber Connect - June 12 - 14, 2017 - Orlando, FL

Booth #647

Visit booth #647 at NATE Unite 2017 to see how KGP Logistics can add efficiency and value to your 2017 wireless projects.
NATE Unite - February 27 - March 2, 2017 - Fort Worth, TX
Communication Situation?

Depend on PREMIER for Structured Wiring Solutions to Patch Ground Connectorize & Optimize

PREMIER products are available exclusively through KGP Logistics. Contact 800-328-5142 today!

www.DependonPREMIER.com
800.328.5142
We’re not good at everything...

But, we’re darn good at building FTTx Networks

Sometimes the pros make things look easier than they really are. We’re not professional mountain bikers, but we are when it comes to engineering smaller, more efficient products for your FTTx installations. We know it’s important to plan for future growth and space is at a premium. Our new line of MDU Solutions gives you all the same features as the other guys but with a much smaller footprint. They always say, “stick to your strengths” and with more than 30 years in the industry we’ve certainly learned a thing or two. So we’ll leave the biking to the pros and keep working to bring you new and innovative FTTx solutions.

FTTx MDU Solutions
- Exterior Distribution Cabinets
- Mini Interior Distribution Cabinets
- MDU Entrance Enclosures
- MDU Drop Cable Assemblies
- Wall Mount Enclosures
- Splicing and Distribution Enclosures
- Field-Installable Connectors

Get the FTTx Brochure. Visit: AFLglobal.com/Access
Meeting the Unique Test Challenges of FTTx Deployment

Michael Scholten, Sr. Product Marketing Manager, AFL

Synopsis
Passive optical networks are being deployed worldwide to more cost-effectively deliver high-bandwidth broadband services to subscribers. FTTx PONs present unique installation verification and maintenance troubleshooting challenges. These challenges are effectively overcome when technicians understand FTTx PON architecture and are equipped with test tools designed to address the unique test requirements of FTTx PONs.

Introduction
Rapid growth of fiber optic networks has resulted in an explosion of improved services to the residential consumer. Fiber to the home (FTTH or FTTx) passes more than 262 million homes globally, 20 million of which are in the United States. As telecommunications companies replace old copper technologies with fiber, they are able to deliver more bandwidth, reliability, flexibility and security to end-users.

While many carriers with deployed twisted-pair copper networks utilize increasingly complex DSL technology to deliver broadband services, bandwidth demand will ultimately exceed the capacity which can be delivered over those networks.

With nearly unlimited bandwidth, FTTH fiber networks are becoming the go-to technology for next-generation communications worldwide, including distance learning, cloud computing, tele-medicine and more. Additionally, many governments have sponsored broadband plans to install and improve this critical fiber infrastructure in remote and rural areas.

FTTH passive optical networks (PONs) are increasingly being deployed to provide optical fiber’s bandwidth advantages at a lower cost than point-to-point architecture affords. However, PONs present unique test challenges when installing and maintaining the FTTH network. This white paper provides an overview of FTTx PON architectures, identifies test challenges unique to FTTx PONs, and describes optical tests recommended to verify or troubleshoot FTTx PONs, including in-service (live) PONs.

FTTH Network Architectures
FTTH networks may be deployed using either point-to-point or point-to-multipoint network architecture.

Point-to-point architectures include active Ethernet, and offer a dedicated fiber connection from the operator’s local exchange—either a central office (CO) or powered, environmentally-controlled vault (EV)—to each subscriber’s premise. A point-to-point architecture also requires electro-optics for each subscriber at both CO or EV and the customer premise.

Gigabit-capable passive optical network (GPON) and Ethernet passive optical network (EPON) are two PON technologies commonly deployed in point-to-multipoint networks. In both GPON and EPON networks, active electronics are located only at the end-points of the PON, reducing network cost and increasing network reliability. An optical line terminal (OLT) residing in the carrier’s CO communicates across the passive optical distribution network (ODN) to optical network terminals (ONTs) located at subscribers’ premises (see Fig. 1).
In the ODN, a single feeder fiber connects the CO to a pedestal- or pole-mounted fiber distribution hub (FDH). The FDH may be located in a neighborhood or the entry level of a multi-dwelling unit (MDU).

In single splitter PON architectures, a single 1x32, 1x64 or 1x128 splitter is installed at the FDH. A feeder fiber connects the central office to the splitter at the FDH. This splitter separates the downstream signal into 32, 64, or 128 copies. Each of the many splitter ports are then connected through a distribution fiber to a pedestal- or pole-mounted Access Point (AP) terminal. A drop fiber connects each AP terminal to an ONT installed at each subscriber’s premise. The ONT may be installed either inside or outside the customer premise.

In a distributed PON, two lower split ratio splitters are installed, one at the FDH followed by a second splitter at the multi-port access terminal. The effective split ratio in a distributed PON is the multiple of the distributed splitters (e.g. 1x4 followed by 1x8 results in an effective split ratio of 1x32). This configuration may be used in rural applications to save fiber, or in dense applications, such as MDUs or apartment buildings. For example, drop fibers from a secondary splitter located in the entry level of an MDU would connect to each subscriber’s apartment.
A PON’s trunk-and-branch architecture reduces the amount of fiber required. Additionally, the downstream signal is broadcast to all attached subscribers, so a single downstream transmitter serves multiple customers. In the upstream direction, subscribers are assigned unique time slots in which to transmit, with the signals from the subscribers combined at the passive splitter and sent to the CO over the single feeder fiber. Consequently, a single CO receiver also serves multiple customers.

**Traffic on the network**

Both GPON and EPON deliver voice, data, and IP video signals downstream using 1490 nm wavelength. An optional video overlay may be transmitted downstream at 1550 nm. Voice and data is communicated upstream from the ONT on the same fiber using 1310 nm wavelength.

Downstream signals are optically divided at the splitter into multiple identical signals. The optical power of each signal is reduced by the split ratio plus some additional insertion loss. For example, the optical power level through a 1x32 splitter is reduced by approximately 16 dB, which is slightly more than a factor of 32. While each ONT sees the same downstream signal, downstream data is encrypted and addressed to specific ONTs, so each ONT can only access data addressed to it.

In the upstream direction, multiple subscribers may simultaneously wish to send data upstream to the CO. Since all ONTs use the same 1310 nm upstream wavelength, time division multiple access (TDMA) is used to prevent multiple ONTs from sending signals at the same time. With TDMA, the OLT assigns each ONT unique time slots during which it can send data in the upstream direction, preventing multiple ONTs from transmitting simultaneously.

**FTTH PON Testing Overview**

Proper testing is a critical part of installing, activating and maintaining a PON. While most components are tested during the manufacturing process, they are tested again after splicing and installation of splitters and access terminals. Field testing is required to ensure no excess loss or reflectance has been introduced due to micro-bends in installed fiber, poor splices, macro-bends in splice closures or access terminals, or dirty, damaged, or improperly seated connectors. If not detected and corrected, excess loss or reflectance often results in poor network performance. Performance may initially seem acceptable, but over time, transmission errors may begin to increase long before the need for any maintenance activity would normally be expected.

Tests commonly used to verify optical links include the following:

- Connector inspection
- Insertion loss test
- Optical return loss test
- Optical time domain reflectometry (OTDR)

Connector inspection and cleaning during installation and maintenance are among the most effective methods for ensuring an optical network will deliver expected performance. Connector inspection is typically performed using an optical microscope. To prevent accidental eye damage when inspecting fibers potentially carrying live traffic, a video microscope images the connector end-face and displays the magnified image on a handheld display. Dirt, debris, or damage are easily detected. Images may be captured before and after cleaning, then compared for any variation. Connector contamination and damage are the most common causes of poor optical network performance, according to a recent study by NTT-Advanced Technology.2
An **insertion loss test** measures the end-to-end loss of the installed link by injecting light with a known power level and wavelength at one end, and measuring the received power level output from the other end. The measured difference between the transmitted and received power levels indicates the optical loss through the network. Insertion loss is considered acceptable when the measured loss level is lower than the budgeted loss level.

An **optical return loss test** injects light with known wavelength and power level into one end and measures the power level returned to that same end. The difference between the injected power level and the measured return level is the return loss. Return loss is considered acceptable when it is higher than the budgeted return loss target. A low return loss value (below 35 dB) is often an indication of one or more sources of excess reflection in the network under test, typically due to dirty or damaged connectors or a fiber break.

Since optical network loss is wavelength-dependent, insertion and return loss testing is typically performed using wavelengths at or near those which will be used during network operation. In the case of FTTx PONs, downstream wavelengths of 1490 nm and 1550 nm may be used, while 1310 nm is used in the upstream direction. Consequently, insertion and return loss testing at 1310 nm, 1490 nm, and 1550 nm may be required. In practice, testing is often performed only at 1310 nm and 1550 nm, reasonably expecting loss and return loss at 1490 nm to be between the levels measured at 1310 nm and 1550 nm.

If the loss and return loss measured at each wavelength are within the levels budgeted for the link, the optical network may be considered ready for activation. However, in many cases, the network operator requires the network to be more fully documented using an optical time domain reflectometer (OTDR).

An **OTDR** scans a fiber from one end to measure the length, loss and optical return loss of an optical network. It also locates and measures reflective and non-reflective events in the network due to splices, connectors, micro- or macro-bends, splitters or faults.

Operating like a radar, an OTDR injects narrow pulses of light into the fiber-under-test. As each pulse travels down the fiber, imperfections in the fiber scatter some of the light, with some of this Rayleigh-scattered light being guided back up the fiber.

Optical pulses and backscatter experience some loss as they traverse a mated connector pair, mostly due to imperfect alignment between the two connectors. By measuring the difference between backscatter levels before and after the connection, the OTDR is able to measure the loss across each connection.

A Fresnel reflection is generated whenever the pulse encounters a mismatch in the index-of-refraction, usually at a mated connector. An air gap at a poorly mated connector or an open connector end will generate a strong reflection. This reflected energy is also guided back up the fiber. (Note: The ends of APC connectors are angled to ensure that light is reflected off the end-face at such an angle that it is not captured and guided back up the fiber.)

The OTDR measures the level of returned backscatter and reflections vs. time. Since the speed of light through the optical fiber is known, the OTDR is able to convert time-of-flight into distance, creating a trace which plots changes in backscattered and reflected light levels vs. fiber length. Losses due to connectors or macro-bends appear as abrupt changes in the backscatter signal level. Reflections due to connectors, air gaps and open ends appear as spikes in the OTDR trace, as shown in Fig. 2.
End-to-end loss is measured by comparing backscatter level at the beginning of the fiber to backscatter level at the end of the fiber. Reflectance levels are determined by comparing the backscatter level just before a connector to its reflective spike level. Optical return loss can be computed by summing end-to-end backscatter and reflection levels and comparing them to the transmitted pulse power level.

For more accurate connector or end-to-end loss measurements, OTDR traces from opposite ends of a point-to-point network are often averaged using PC-based trace analysis software. Note: Insertion and return loss tests each provide a single numeric value which can be compared to network-specific limits to determine if the optical plant is within acceptable performance values. However, when unacceptable or marginal values are found, insertion or return loss tests cannot locate the source of the problem. An OTDR also measures loss and return loss, but can additionally locate the sources of excess loss and reflections, reporting the distance to high loss or highly reflective events.
Which Tests, When and Where?

Optical testing is typically performed at various points in a network’s lifetime:

Installation verification testing occurs as the network is being constructed or after network installation is complete, but before the network is activated. This is usually when the most complete testing is performed, and may include insertion and return loss testing as well as OTDR testing. Pass/fail criteria may be applied to end-to-end length, loss and ORL results, as well as to individual event loss and reflectance measurements for splices, connectors, and splitters. Formal reports may be generated, including all of the measurements, OTDR traces, pass/fail criteria and pass/fail results.

Maintenance troubleshooting is performed when service outages occur, and typically requires rapid response to restore service as quickly as possible. This is done through reroute restoration and/or fault location, repair, and verification before restoring active service. Troubleshooting may also require nondisruptive fiber identification to ensure in-service fibers are not disconnected. Maintenance personnel may require a visual fault locator (VFL) to precisely pinpoint the location of breaks or macro-bends in splice or access enclosures.

Table 1 summarizes installation and maintenance tests which may be performed, indicates the equipment required for each test, when the test is most likely to be performed (e.g. during installation or troubleshooting), typical test wavelengths, and where the test is performed.

### Table 1 — FTTx PON Installation Verification and Maintenance Troubleshooting Tests

<table>
<thead>
<tr>
<th>TEST</th>
<th>DESCRIPTION</th>
<th>WHEN USED</th>
<th>REQUIRED EQUIPMENT</th>
<th>WAVELENGTHS (NM)</th>
<th>TEST FROM</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-of-Service Feeder Fiber Test</td>
<td>Test insertion loss of feeder fiber before splitter installed (OLT &lt;-&gt; FDH)</td>
<td>Yes</td>
<td>OLS &amp; OPM</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>OLT to FDH, or FDH to OLT, or Both (bidirectional)</td>
<td>Does not verify connection to splitter; Either test requires equipment at both ends; Wave ID shortens test time and eliminates setup errors</td>
</tr>
<tr>
<td></td>
<td>Test insertion loss of feeder fiber after splitter installed (OLT &lt;-&gt; FDH)</td>
<td>Yes</td>
<td>OLS &amp; OPM</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>OLT to FDH, or FDH to OLT, or Both (bidirectional)</td>
<td>Test through any splitter port verifies feeder fiber and splitter connection; Must test through all splitter ports to verify each splitter port is OK</td>
</tr>
<tr>
<td></td>
<td>OTDR test of feeder fiber before splitter installed (OLT &lt;-&gt; FDH)</td>
<td>Yes</td>
<td>OTDR</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>OLT to FDH, or FDH to OLT, or Both (bidirectional)</td>
<td>Locate all splices and connectors; Verify no excess losses or reflections, or locate any excess losses and reflections for repair</td>
</tr>
<tr>
<td></td>
<td>OTDR test of feeder fiber after splitter installed (OLT -- Splitter)</td>
<td>Yes</td>
<td>OTDR</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>OLT</td>
<td>Locate all splices and connectors; Verify no excess losses or reflections, or locate any excess losses and reflections for repair; Does not test individual splitter ports</td>
</tr>
<tr>
<td></td>
<td>OTDR test of feeder fiber after splitter installed (Splitter -- OLT)</td>
<td>Not recommended</td>
<td>Possibly OTDR</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>Splitter ports</td>
<td>Not recommended for verifying feeder fiber splices since wide pulse width (low resolution) required to see through splitter to detect &amp; verify low-loss splices; May be used to verify loss through each splitter port.</td>
</tr>
</tbody>
</table>
Table 1—FTTx PON Installation Verification and Maintenance Troubleshooting Tests

<table>
<thead>
<tr>
<th>TEST</th>
<th>DESCRIPTION</th>
<th>WHEN USED</th>
<th>REQUIRED EQUIPMENT</th>
<th>WAVELENGTHS (NM)</th>
<th>TEST FROM</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-of-Service Splitter, Distribution &amp; Drop Fiber Tests</td>
<td>Test insertion loss of feeder fiber, splitter and distribution fiber (drop fiber not installed)</td>
<td>Yes</td>
<td>No</td>
<td>OLS &amp; OPM</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>OLT to AP; or AP to OLT, or Both (bidirectional)</td>
</tr>
<tr>
<td></td>
<td>Test insertion loss of feeder fiber, splitter, distribution, and drop fibers</td>
<td>Yes</td>
<td>Possibly</td>
<td>OLS &amp; OPM</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>OLT to OLT, or OLT to ONT, or Both (bidirectional)</td>
</tr>
<tr>
<td></td>
<td>OTDR test of splitter plus distribution fiber (drop fiber not installed) (PON out-of-service)</td>
<td>Yes</td>
<td>Possibly</td>
<td>OTDR</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>AP toward OLT</td>
</tr>
<tr>
<td></td>
<td>OTDR test of splitter, distribution and drop fibers (PON out-of-service)</td>
<td>Yes</td>
<td>Possibly</td>
<td>OTDR</td>
<td>1310/1550 or 1310/1490/1550</td>
<td>ONT toward OLT</td>
</tr>
<tr>
<td>In-service Distribution &amp; Drop Fiber Tests</td>
<td>Test end-to-end insertion loss of PON</td>
<td>Not typical</td>
<td>Possibly</td>
<td>OLS &amp; OPM</td>
<td>1625 or 1650</td>
<td>OLT to OLT, or OLT to ONT, or Both (bidirectional)</td>
</tr>
<tr>
<td></td>
<td>OTDR test of splitter, distribution and drop fibers (PON in-service)</td>
<td>No</td>
<td>Yes</td>
<td>OTDR</td>
<td>1625 or 1650</td>
<td>ONT toward OLT</td>
</tr>
<tr>
<td></td>
<td>Measure downstream power level</td>
<td>No</td>
<td>Yes</td>
<td>PON OPM</td>
<td>1490, 1550</td>
<td>ONT</td>
</tr>
<tr>
<td></td>
<td>Pinpoint faults in AP, FDH or splice closure</td>
<td>Yes</td>
<td>Yes</td>
<td>VFL</td>
<td>635 or 650</td>
<td>ONT toward AP, FDH</td>
</tr>
<tr>
<td>Active ONT detection</td>
<td>Non-intrusively detect active ONT</td>
<td>No</td>
<td>Yes</td>
<td>Active ONT Identifier</td>
<td>1310 nm</td>
<td>900 µm, 2 or 3 mm fiber between splitter and ONT</td>
</tr>
<tr>
<td>Fiber Identification</td>
<td>Non-intrusively detect live fiber</td>
<td>Possibly</td>
<td>Yes</td>
<td>OFI</td>
<td>1310/1490/1550</td>
<td>900 µm, 2 or 3 mm fiber between splitter and ONT</td>
</tr>
<tr>
<td></td>
<td>Non-intrusively detect out-of-service fiber carrying test tone</td>
<td>Possibly</td>
<td>Yes</td>
<td>OLS &amp; OFI</td>
<td>1310/1490/1550</td>
<td>900 µm, 2 or 3 mm fiber between splitter and ONT</td>
</tr>
</tbody>
</table>
FTTx PON Insertion Loss Tests

Insertion loss tests are primarily used to test FTTx PONs during installation. Insertion loss testing may be performed on individual fiber segments as they’re installed (e.g. test feeder fiber from CO to FDH, test distribution fiber from FDH to AP, or test drop fiber from AP to subscriber’s premise). An end-to-end insertion loss test may also be performed on the FTTx PON after it is partially or fully installed (from CO through feeder fiber, splitter, distribution and drop fibers to the AP or customer’s premise).

A stable optical light source and an optical power meter are required to measure insertion loss. Access to both ends of the fiber-under-test is required. Consequently, this is typically an out-of-service test.

To measure loss, received power at the far end of the fiber-under-test must be compared to transmit power injected into the fiber at the near end of the fiber under-test. To simplify loss measurements, the power meter is initially connected to the source with a short jumper cable and the source power level is measured and stored as the 0 dB reference level for that wavelength. Since the source's output power levels and the power meter’s detector response are different at each wavelength, the power meter must be referenced to the source at each test wavelength.

Once the source and power meter have been referenced at each of the test wavelengths, the source—with the reference jumper still attached—is connected to one end of the fiber under test. The power meter is connected to the other end of the fiber-under-test. Received power level is measured and displayed. More conveniently, the power meter can compare the received power level to the stored reference, directly displaying optical loss in dB.

Simple power meters measure power at only one wavelength at a time. To make loss measurements at multiple wavelengths, the source must be configured for each test wavelength in turn. At the same time, the power meter operator must select the appropriate wavelength at the power meter so the correct detector calibration factor and reference level are applied. This is both time-consuming and error prone, as it requires coordination between the source operator on one end and the power meter user at the other end of the fiber-under-test.

To reduce test time and eliminate this potential for errors, AFL’s FLX380 FlexTester includes Wave ID. A Wave ID source alternately transmits light at each wavelength. A Wave ID power meter automatically synchronizes to the received wavelengths, eliminating the need for source and power meter to be manually switched between wavelengths (see Fig. 3).
FTTx PON Out-of-Service OTDR Tests

OTDR testing is typically completed as the FTTx PON is being deployed. The feeder fibers connecting CO to FDH are typically the longest links in the PON, are usually the first fibers installed, and may include multiple splices. These may be tested as point-to-point links before the splitter is installed at the FDH.

If a splitter is spliced to the feeder fiber before testing, the loss through each of the splitter legs may be verified. However, this requires testing from each of the multiple splitter outputs, and requires a launch fiber (1000 m recommended) to allow the splitter loss to be clearly seen and measured. Splitter losses through each of the legs cannot be easily verified by testing from the CO end of the feeder fiber.

Using an OTDR, distribution fibers are typically tested after installation and connection to the splitter. Once attached to the splitter, these fibers may only be tested from the downstream access point or subscriber premise (if the drop fiber is also installed and connected). High-resolution of the distribution and drop fibers may be obtained using narrow pulses, but the OTDR may not be able to measure the splitter loss using narrow pulses. Wider pulses improve the OTDR’s dynamic range, enabling it to more accurately measure the loss of the attached splitter.

OTDR testing during FTTx PON installation testing is usually performed only at 1310 and 1550 nm. During operation, the FTTx PON always utilizes 1490 nm in the downstream direction and 1310 nm in the upstream direction. It may additionally utilize 1550 nm as a second downstream wavelength. Fiber loss is highest at 1310 nm and lowest at 1550 nm, while bending-induced loss is highest at 1550 nm.

If end-to-end loss is within acceptable limits at both 1310 and 1550 nm, it is nearly certain to be acceptable at 1490 nm. If no excess losses or reflections are found at 1310 or 1550, none are likely to be found at 1490 nm. Even if the PON will initially be operated using only 1490 and 1310, testing at 1310 and 1550 nm can detect any micro- or macro-bends, and ensures the FTTx PON is capable of adding 1550 nm operation in the future.

Fig. 3—Store reference and measure loss using Source and Power Meter with Wave ID
Troubleshooting an In-Service FTTx PON

Because of its point-to-multi-point architecture, it is possible for one or only a few subscribers to lose service while other subscribers on the same PON continue to receive service. There are several possible causes:

- Equipment or connection problem inside the customer’s premise;
- Failed ONT at the customer’s premise;
- Fault in the distribution or drop fiber from the splitter to the subscriber;
- Fault introduced at the splitter connection to the subscriber’s distribution or drop fiber (e.g. macro-bend introduced while adding another subscriber, or inadvertently disconnecting the distribution or drop fiber to an active subscriber).

If some, but not all subscribers are affected in an FTTx PON built using distributed splitter architecture, it is possible that all of the affected customers are served from a single secondary splitter. In this case, likely causes include:

- Fault in the distribution fiber serving the secondary splitter;
- Fault in the secondary splitter itself.

In either case, a fault in the feeder fiber or a failure within the OLT is not likely, since the feeder fiber and OLT are also shared by subscribers who are still receiving service.

Troubleshooting normally requires a visit to the subscriber’s premise. A recommended troubleshooting process is illustrated in Fig. 4 and described on pages 11 and 12.
Fig. 4—Troubleshooting a Live PON
Test Procedure when Troubleshooting an In-Service (Live) PON

1. Use an Active ONT Identifier to determine if the ONT at the subscriber’s premise is responding to downstream signals from the OLT. The Active ONT identifier clamps on to 900 µm buffered fiber, or 2 or 3 mm jacketed fiber, senses and reports the presence or absence of the 1310 nm upstream response from an active ONT.

2. If an active ONT is detected, the fault is either an equipment or connection problem inside the customer’s premise (most likely), or the ONT itself (less likely). Optical tests at the ONT are unlikely to resolve the problem.

3. If an active ONT is not detected, the fault may either be a failed ONT or a fault in the splitter, distribution or drop fiber connecting the feeder fiber to the subscriber.

4. In this case, disconnect the drop fiber from the ONT, inspect and clean the optical connectors on the drop fiber and the ONT. If a damaged optical connector is found on the drop fiber, replace, clean and inspect the new connector before proceeding. If a damaged optical connector is found on the ONT, the ONT likely will have to be swapped out.

5. If connectors are clean and undamaged, check the downstream power level at the ONT using a PON Power Meter. Some OTDRs include a PON Power Meter integrated into their OTDR port, enabling immediate detection and measurement of downstream power levels at both 1490 and 1550 nm.

6. If the measured downstream power levels are acceptable, the problem is likely a failed ONT. Swap out the ONT, clean and reconnect the drop fiber, and verify the ONT synchronizes to the upstream OLT.

7. If the measured downstream power level(s) are not acceptable, the problem is likely a fault in the distribution or drop fiber, or a fault introduced at the splitter in the FDH. In this case, connect a live PON OTDR to the drop fiber and initiate an upstream OTDR test using the out-of-band 1625 nm wavelength. To prevent disrupting service on the live PON, select an OTDR which prevents the user from initiating 1310, 1490, or 1550 nm OTDR tests when live traffic is present.

8. Some OTDRs also allow the operator to test only the customer fiber (distribution and drop), or to test through the splitter. Unless multiple customers are affected, the problem is most likely in the distribution and drop fiber, so testing only the distribution and drop fiber is a good bet.

9. Review the 1625 nm trace and event table to determine if there is a break or any excess losses or reflections in the distribution and drop fibers. If so, locate the problem location, repair the fault, then verify the fix by rescanning the fiber using the same 1625 nm test. To precisely pinpoint macrobends or breaks within a splice enclosure or access point, disconnect the OTDR and connect a Visual Fault Locator (VFL, a visible red laser). Enable the VFL and look for the point where the fault causes red light to escape from the fiber.

10. If no excess losses or reflections were identified in the OTDR trace, rescan the FTTx PON from the same location at 1625 nm using the “Test through Splitter” setup. This will provide a trace of the distribution and drop fibers with sufficient dynamic range to see through the splitter and measure the splitter loss. Since other probable causes have been eliminated, likely problems are a break or macrobend at the splitter, or the splitter has been disconnected from the distribution fiber. These will manifest themselves either as excess loss at the splitter, or as the fiber end being detected at the splitter. Repair the fault, then verify the fix by rescanning the fiber using the same setup.

11. Once fiber restoration is complete, verify the proper downstream power levels are available at the end of the drop fiber, clean and reconnect the drop fiber to the ONT, and verify the ONT synchronizes to the upstream OLT.
Summary
Passive optical networks are being deployed worldwide to more cost-effectively deliver higher bandwidth broadband services to subscribers. FTTx PONs present unique installation verification and maintenance troubleshooting challenges. These challenges are effectively overcome when technicians understand FTTx PON architecture and are equipped with test tools designed to address the unique test requirements of FTTx PONs.

Notes:
2 NTT—Advanced Technology; http://www.bicsi.org/uploadedFiles/PDFs/Presentations/Fibre%20Optic%20Connector.pdf

About Michael Scholten
Michael is Sr. Product Marketing Manager at AFL, one of the world’s leading manufacturers of fiber optic cable. The company’s diverse product portfolio includes fibre optic cable, transmission and substation accessories, outside plant equipment, connectors, fusion splicers, test equipment and training. AFL’s service portfolio includes market-leading positions with the foremost communications companies supporting inside plant central office, EF&I, outside plant, enterprise and wireless areas.

FTTx MDU Solutions
- Exterior Distribution Cabinets
- Mini Interior Distribution Cabinets
- MDU Entrance Enclosures
- MDU Drop Cable Assemblies
- Wall Mount Enclosures
- Splicing and Distribution Enclosures
- Field-Installable Connectors

Get the FTTx Brochure. Visit:
AFLglobal.com/Access

Contact KGP Logistics for more information about AFL, FTTx products
www.kgplogistics.com | 800-328-5142
### 3M

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000418437</td>
<td>80611387558</td>
<td>SFFW-J-1/2 SLIM LOCK CLOSURE FOR 1/2&quot; DIN 7/16 CONNECTOR</td>
</tr>
<tr>
<td>0000434896</td>
<td>80611495971</td>
<td>Slim Lock Closure, SLC-A-MINI</td>
</tr>
<tr>
<td>Contact KGP Logistics</td>
<td>80611495989</td>
<td>SLC-B-NANO SLIM LOCK CLOSURE 0.51-0.62 CONN NECK 1/2IN CABLE</td>
</tr>
</tbody>
</table>

### ADTRAN

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000407753</td>
<td>1287703G1</td>
<td>TA374 4 POTS + 4 GE MDU</td>
</tr>
<tr>
<td>0000436104</td>
<td>1287703G1S</td>
<td>TA374 4 POTS + 4 GE MDU(S)</td>
</tr>
<tr>
<td>0000432913</td>
<td>1287733F1</td>
<td>TA480 OUTDOOR MDU ENCLOSURE</td>
</tr>
</tbody>
</table>

### AFL

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8800003153</td>
<td>FLX380-303-CMP2</td>
<td>Flextester3 CMP2 Kit(Hard Case,FOCISFlex,One-Click),Mod303(41/41/38@1310/1550/1625),APC Ferrule,TRM &amp;LM, English, ASC Bulkhead;2.5 APC Ferrule;2.5 Cleaning, FR1-SM-150-ASC-ASC, 400-Jacketed &amp; Buffered Fiber;Power &amp; Tone Display</td>
</tr>
<tr>
<td>8800002925</td>
<td>FLX380-303A-ENG-STD</td>
<td>Flextester3 Standard Kit(Soft case,One-click),Mod 303(41/41/38@1310/1550/1625),APC Ferrule,TRM only, English</td>
</tr>
<tr>
<td>0000420642</td>
<td>FLX380-303A</td>
<td>Flex Tester3 Kit, FLX380-303A, 1310/1550/1625, APC</td>
</tr>
<tr>
<td>0000408219</td>
<td>S015671</td>
<td>Fujikura 70R Fusion Splicer Kit w/CT-30,BTR-09,DC-18</td>
</tr>
<tr>
<td>0000397667</td>
<td>S015591</td>
<td>70S Fusion Splicer Kit w/ CT30A</td>
</tr>
<tr>
<td>0000087449</td>
<td>VF12-00-0900PR</td>
<td>Visual Fault Identifier FDA &amp; IEC Class II Laser 650NM Wavelength 1MW Output 2HZ or CW Selected Modulation Universal Adapter 2.5mm Battery Powered AA Alkaline 5.5”X 2.4” X 1.3” 7.06oz</td>
</tr>
</tbody>
</table>

### APC by Schneider Electric

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>000035106</td>
<td>SMT1500RM2U</td>
<td>APC Smart-UPS, 1000 Watts / 1500 VA, Input 120V / Output 120V, Interface Port SmartSlot, USB, Rack Height 2 U</td>
</tr>
</tbody>
</table>

### CommScope

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000427343</td>
<td>L4A-DMDM-10-P-SGW</td>
<td>10’ Din Male-Din Male LDF4 SureGuard Jumper - PIM Rated</td>
</tr>
<tr>
<td>0000387380</td>
<td>L4A-DMDM-8-P</td>
<td>8’ Din Male-Din Male LDF4 SureFlex Jumper - PIM Rated</td>
</tr>
<tr>
<td>0000417117</td>
<td>158E2NF</td>
<td>1-5/8” N-Female Connector</td>
</tr>
<tr>
<td>0000413371</td>
<td>SSH-114</td>
<td>1-1/4” Stackable Snap In Hangers</td>
</tr>
<tr>
<td>0000417361</td>
<td>SSHAK-3812</td>
<td>3/8” Stackable Snap In Hangers</td>
</tr>
<tr>
<td>0000408373</td>
<td>FT-TB</td>
<td>Black Silicone Weatherproofing Tape</td>
</tr>
<tr>
<td>0000417387</td>
<td>UGBK10412-T</td>
<td>1/4”X4”X12” Tinned Copper Ground Bar With Universal Hardware</td>
</tr>
<tr>
<td>0000416817</td>
<td>SBNH-1D6565A</td>
<td>Quad Port Antenna 698-896/1710-2180MHz</td>
</tr>
<tr>
<td>0000391093</td>
<td>SF-SU12-B</td>
<td>12’-6” Sector Frame - Purchase Antibenna Pipes Separately</td>
</tr>
<tr>
<td>0000417405</td>
<td>SF-QV12-B</td>
<td>12’-6” QV Folding Sector Frame - Purchase Antibenna Pipes Separately</td>
</tr>
<tr>
<td>0000433108</td>
<td>VSR-TS-B</td>
<td>Stabilizer Kit For QV Folding Sector Frame</td>
</tr>
<tr>
<td>0000391081</td>
<td>MC-PA12L-B</td>
<td>12’ Monopole Co-Location Platform For 30-30’ Monopole - Purchase Pipes Separately</td>
</tr>
<tr>
<td>0000409907</td>
<td>WB-K210-B</td>
<td>24” x 10’ 2 Post Direct Burial Waveguide Bridge Kit</td>
</tr>
<tr>
<td>0000387437</td>
<td>SM-U2080</td>
<td>Universal Saddle Mount</td>
</tr>
<tr>
<td>0000387452</td>
<td>XP-2020</td>
<td>Crossover Plate For 2-3/8” Pipe</td>
</tr>
<tr>
<td>0000387411</td>
<td>MT-651-96</td>
<td>2-3/8” x 96” HDG Antenna Pipe</td>
</tr>
<tr>
<td>0000368963</td>
<td>CMAX-DM60-CPUSEI</td>
<td>MIMO DAS Antenna 698-960/1710-2700 Mhz</td>
</tr>
<tr>
<td>0000369031</td>
<td>T-2-DM</td>
<td>2 Watt DIN Male Termination</td>
</tr>
</tbody>
</table>

### Comtrend

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000462066</td>
<td>WAP-PC1200C</td>
<td>AC1200 Dual Band Wireless Access Point, (400mW) High Power, High Sensitivity, Ceiling Mount</td>
</tr>
<tr>
<td>8800003966</td>
<td>WAP-EN1200C</td>
<td>AC1200 Managed Dual Band Wireless Access Point, (400mW) High Power, High Sensitivity, Ceiling Mount</td>
</tr>
</tbody>
</table>

### Preformed Line Products

Contact KGP Logistics for more information
### PREMIER

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Vendor No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDMI Cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0000439302</td>
<td>PT-HDMI-1.4V-6FT</td>
<td>HDMI Cable, Male to Male, 6' High Speed with Ethernet Version 1.4</td>
</tr>
<tr>
<td>0000439303</td>
<td>PT-HDMI-1.4V-10FT</td>
<td>HDMI Cable, Male to Male, 10' High Speed with Ethernet Version 1.4</td>
</tr>
<tr>
<td>0000439304</td>
<td>PT-HDMI-1.4V-12FT</td>
<td>HDMI Cable, Male to Male, 12' High Speed with Ethernet Version 1.4</td>
</tr>
<tr>
<td>Station Wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010827500</td>
<td>SW-C3X-2P22BG-P1000</td>
<td>2 Pair 22 Gauge CMX Category 3 1000 Foot Pop Box Beige</td>
</tr>
<tr>
<td>3043867500</td>
<td>SW-C3X-2P24BG-P1000</td>
<td>2 Pair 24 Gauge CMX Category 3 1000 Foot Pop Box Beige</td>
</tr>
<tr>
<td>3043887500</td>
<td>2137142</td>
<td>4 Pair 24 Gauge CMX Category 3 1000 Foot Pop Box Beige</td>
</tr>
<tr>
<td>3000014266</td>
<td>2137146E</td>
<td>4 Pair 24 Gauge CMX Category 5e 1000 Foot Pop Box Gray</td>
</tr>
<tr>
<td>3000028204</td>
<td>2137113E</td>
<td>4 Pair 24 Gauge CMX Category 5e 600 Foot Pop Box Ivory</td>
</tr>
<tr>
<td>3000031726</td>
<td>51-240-31</td>
<td>4 Pair 24 Gauge CMX Category 5e 1000 Ft Pop Box Beige-Superior Essex</td>
</tr>
<tr>
<td>3000031727</td>
<td>51-240-21</td>
<td>4 Pair 24 Gauge CMX Category 5e 1000 Ft Pop Box Blue-Superior Essex</td>
</tr>
<tr>
<td>3000032945</td>
<td>51-240-11</td>
<td>4 Pair 24 Gauge CMX Category 5e 1000 Ft Pop Box Beige-Superior Essex</td>
</tr>
<tr>
<td>Coax Cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000185515</td>
<td>2137144E</td>
<td>4 Pair 24 Gauge CMX Category 5e 1000 Foot Pop Box Beige</td>
</tr>
<tr>
<td>00000282004</td>
<td>2137113E</td>
<td>4 Pair 24 Gauge CMX Category 5e 600 Foot Pop Box Ivory</td>
</tr>
<tr>
<td>0000108097</td>
<td>C5775.31.01</td>
<td>RG6 Coax General Purpose CM 60% Braid 1000 Foot Pop Box Black</td>
</tr>
<tr>
<td>0000108098</td>
<td>C5775.31.02</td>
<td>RG6 Coax General Purpose CM 60% Braid 1000 Foot Pop Box White</td>
</tr>
<tr>
<td>0000108099</td>
<td>C5775.41.01</td>
<td>RG6 Coax General Purpose CM 60% Braid 1000 Foot Reel Black</td>
</tr>
<tr>
<td>Telect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0377330217</td>
<td>0377330217</td>
<td>WaveTrax FastLock Couplers 4&quot;</td>
</tr>
<tr>
<td>0011580000</td>
<td>027-2000-6499</td>
<td>WaveTrax FastLock Couplers 6&quot;</td>
</tr>
<tr>
<td>Contact KGP Logistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0000438619</td>
<td>027-2000-6412</td>
<td>WaveTrax Express T’s 6&quot;</td>
</tr>
<tr>
<td>Contact KGP Logistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0000420636</td>
<td>027-2000-4262</td>
<td>WaveTrax Express Off-Ramps 2&quot;</td>
</tr>
<tr>
<td>0000420635</td>
<td>027-2000-4062</td>
<td>WaveTrax Express Off-Ramps 4&quot;</td>
</tr>
<tr>
<td>5132730217</td>
<td>027-0000-4200</td>
<td>WaveTrax CableLinks 2&quot;</td>
</tr>
<tr>
<td>0257150217</td>
<td>027-0000-4000</td>
<td>WaveTrax CableLinks 4&quot;</td>
</tr>
<tr>
<td>0257190217</td>
<td>027-0000-6400</td>
<td>WaveTrax CableLinks 6&quot;</td>
</tr>
<tr>
<td>Viavi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0000477167</td>
<td>FIT-FC-KIT1</td>
<td>FiberChek probe, case, FBPT-U25M, tip case</td>
</tr>
<tr>
<td>0000477168</td>
<td>FIT-FC-KIT2</td>
<td>Kit: FiberChek probe, case, FBPT-LC, FBPT-SC, FBPT-U12M, FBPT-U25M, tip case</td>
</tr>
<tr>
<td>0000477170</td>
<td>FCPP-SCASE3</td>
<td>FiberChek case</td>
</tr>
<tr>
<td>0000477171</td>
<td>FBPP-DPAC7</td>
<td>Locking MicroUSB cable</td>
</tr>
<tr>
<td>0000477172</td>
<td>FBPP-DPAC8</td>
<td>OTG cable</td>
</tr>
<tr>
<td>0000477173</td>
<td>FCPP-CHIP1</td>
<td>FiberChek holster</td>
</tr>
<tr>
<td>0000477106</td>
<td>FIT-FC-KIT4C</td>
<td>FiberChek Probe wireless fiber inspection probe, a/c charger, soft carry case; SW-FCM-A1; SC/APC, SC/APC and LC/UPC patchcord and bulkhead inspection tips (6 tips total), MP-60A PM</td>
</tr>
<tr>
<td>0000477107</td>
<td>FIT-SD1000C</td>
<td>FBP-P5000 w/Fibercheckpro SW, Case, Tips, &amp; Adapters; SW-FCM-A1; MP-60A</td>
</tr>
<tr>
<td>0000477108</td>
<td>HST3000-CUDS-L-SILVER</td>
<td>HST3000-CUDS-L-SILVER:Advanced DSL Copper Package</td>
</tr>
<tr>
<td>0000477109</td>
<td>ONX580-DL-BONDED-P1C</td>
<td>ONX-580 DSL Bonded Standard Package</td>
</tr>
<tr>
<td>0000477110</td>
<td>ONX580-DL-HOME-P4C</td>
<td>ONX-580 DSL Bonded Home Standard Package</td>
</tr>
<tr>
<td>0000477177</td>
<td>SmartOTDR126A-P1C</td>
<td>SMARTOTDR CONTRACTOR OTDR PACKAGE, Singlennode, SmartOTDR 1310/1550nm (34/33dB) w/5 Inch Color Touchscreen, Wifi, VFL and PM ports, Light Source, SLM, SmartTEST and ExpertOTDR Modes, Lithium Polymer battery, hands-free carry case, soft carry case</td>
</tr>
<tr>
<td>0000477117</td>
<td>TB2-FCOMP-TK1C</td>
<td>T-BERD 2000 FiberComplete Test Kit, T-BERD 2000 1310/1550nm w/ 5 inch touchscreen color display, power meter, VFL, built-in WiFi module 1310/1550nm, FTTH-SLM Pass/Fail connector inspection software w/P5000x digital inspection probe</td>
</tr>
<tr>
<td>0000477113</td>
<td>TB2-OTDR-TK3C</td>
<td>T-BERD 2000 FTTH CONTRACTOR OTDR Test kit, T-BERD2000 w/ 5 Inch touchscreen color display, built-in power meter, WiFi function, UPC connector, LC connector adapter, light source, cell tower, PON, soft carrying case, hands-free bag</td>
</tr>
<tr>
<td>0000477114</td>
<td>TB2-QUAD-TK2C</td>
<td>T-BERD 2000 QUAD FTTH/ENTERPRISE OTDR PACKAGE, T-BERD2000 platform w/5 Inch touchscreen color display, built-in power meter, VFL, Dual port MM-SC, UPC connector, SC/LC connector adapters, soft carrying case, hands-free bag, AC/DC adapter/charger</td>
</tr>
<tr>
<td>0000477115</td>
<td>TB5800-CPR1-ETH-OTDRC</td>
<td>TBS811P w/ WiFi; CPR1/BERT test options (614M-9.8G); E1/ E3/ E4/ STM-1e/ GE and 10GE LAN/WAN/ incl optics; E4126MA OTDR module w/ LS; FTTH-SLM; FFL-050-2; MP-60A, P5000i No optics</td>
</tr>
<tr>
<td>0000477116</td>
<td>TB5800-DS3-10GE-C</td>
<td>MTSS811P-PDH-10GE/MTS5800 with E1/ E3/ E4/ STM-1e/ GE and 10GE LAN/WAN/ incl optics</td>
</tr>
</tbody>
</table>
Be more than reliable. Be certain.

Forty million customers trust APC by Schneider Electric Smart-UPS.

Smart-UPS® battery backups are protecting more on-premises and cloud-based applications, ensuring your network is available 24/7.

Certainty in a connected world.

Visit KGP Logistics at Booth #110

TECHADVANTAGE® 2017
CONFERECE & EXPO

February 27 – March 1, 2017
San Diego Convention Center
San Diego, CA
The only closure with a full gel seal.

No residue, all gel. 3M™ Slim Lock Closures protect your RF connections by using a gel technology that displaces air around the connector. They’re the only closure with gel on the entire internal surface of the closure.

No drips or drops. Nothing gets by the gel.

3M™ Slim Lock Closures.
Evolutionary wireless weatherproofing from 3M.

www.3M.com/Wireless
KGP Logistics is one of the country’s largest single-source, value-added providers of supply chain services, communications equipment and integrated solutions to the telecommunications industry. We have a diverse and valued customer base, a national logistics network, and a portfolio of manufacturer partnerships that is second to none.

For a complete list of upcoming events visit www.kgplogistics.com/events.html

Follow us on: