The SCOOP

AN EXCLUSIVE PUBLICATION
FOR ELECTRIC COOPERATIVES

VOLUME 2 | ISSUE 2 | APRIL 2023

# POWERING YOUR BROADBAND GOALS

- The Future of PON
- Proactive Grid Monitoring Over Fiber
- Residential Broadband for Utilities

Netceed

The SCOOP

## IN THIS ISSUE



# WELCOME TO THE SCOOP!

Welcome to ***The SCOOP***, our in-house publication solely focused on bringing the electric cooperative, broadband, and manufacturing communities together with relevant information about products and issues impacting the market.

As we're all aware, billions of dollars in federal and private capital funding are being invested into building fiber networks across the country. Of significant relevance is the Broadband Equity, Access, and Deployment (BEAD) Program that formed out of the Infrastructure Investment and Jobs Act, which gives the NTIA a specific allocation formula for distributing $42.45 billion to close the digital divide for the unserved and underserved across the country. While most of the funding has only just begun to flow through the market, electric cooperatives and broadband operators alike will soon embark on the largest fiber optics investment cycle in history.

To assist in your efforts, this publication's focus is to share expertise from across our manufacturing partners and assist in your broadband planning and execution. In this issue, you can read about the role electric cooperatives can play in broadband deployment where 35% of Americans lack access to minimal, acceptable broadband speeds. You can learn how proactive grid monitoring over fiber technology recover costs and future-proof your infrastructure. There is also information on teleprotection of traffic and smart grid services over both the last mile and middle mile.

There is also articles on the future of the passive optical network, the power of fiber optics and what it can mean to your cooperative, IPv6 and the ongoing transition from IPv4, and how to build a resilient broadband business from day one.

We hope you find the content here is focused on helping you add value and purpose to your broadband goals. It's our goal to understand market conditions at both a macro and micro level, while at the same time future-planning our stock and product portfolio to be able to limit any negative exposure to your fiber builds and revenue streams. With more than 13 logistics and distribution centers across the U.S., our one-stop shop model provides a valued resource and true partner to your business.

Netceed

# ETC GROUP UNVEILS NEW FUTURE-FORWARD GLOBAL BRAND

We have some exciting company news! USTC, Walker, Comstar Supply, and Multicom will be changing its name to Netceed.

This year we not only celebrate the Group's 30th anniversary, but also a seminal transformation as we unite together across the Group with a single brand focuses on shaping the future of global communication networks from the core to the service delivery edge.

CEO Cédric Varasteh commented "Our Group has transformed rapidly through acquisitions, organic growth, and Investor backing from Cinven and Carlyle Europe Technology Partners. This momentum and evolution into a singular impactful brand marks a significant milestone for our Group and renews our one team, one vision, one goal mentality under the name Netceed."

The transition to the unified global Netceed brand is planned sequentially over six months, starting with its brands in the U.S., France, and the UK. The company will continue to focus on innovation and dedication to delivering cutting-edge solutions with an unmatched level of telecom industry expertise.

With our new brand, we are becoming an even stronger partner with a fully integrated organization, a global footprint, and a broad product and service portfolio. While staying true to our legacy of enabling our customers' networks and partners to succeed, we're committed to bringing you the best customer experience and technical expertise as a unified organization.

Our unwavering focus is on increasing the speed and reliability of supply chains to open new possibilities for our customers with:

- More certainty in supply availability, on-time delivery, and total cost of ownership (TCO)
- Transformative agility and efficiency for your organization
- Technical expertise and experience in advanced technology and infrastructure solutions

At Netceed, we work hard every day to help deliver the future of communications today by providing our customers with a comprehensive portfolio of core to edge network components and expert product selection, intelligent distribution, product design, and value-added logistics services.

# RURAL ELECTRIC COOPERATIVES ARE AT THE HEART OF COMMUNITY BROADBAND IN RURAL AMERICA

**BY: JUNIPER NETWORKS**

Cooperatives brought electricity and telephone services to rural households nearly a century ago. Today, rural electric cooperatives are ideally positioned to deliver affordable, high-speed broadband to their members. By leveraging federal funding, rural electric cooperatives are taking an increasingly active role in closing the digital divide and ultimately improving access to education, healthcare, and economic opportunities for the communities they serve. At the same time, cooperatives can modernize their operational networks to deliver reliable power at a lower cost.

This article provides insights into a proven success model that addresses both critical challenges simultaneously, along with practical steps that rural electric cooperatives can take to get started.

## The Broadband Opportunity

Thirty-five percent of rural Americans lack access to minimally acceptable broadband speeds, according to the White House. Dial-up and DSL just don't cut it anymore.

Inadequate Internet access was on full display during the pandemic. The FCC estimates that 17 million schoolchildren lacked Internet access. As schools across the nation shifted to remote learning to protect the health and safety of students and teachers, children in Internet deserts were forced to Zoom into their classes from fast-food restaurants or struggle with bandwidth constricted mobile hotspots.

Even before the pandemic, the federal government has been actively working to bridge the gap. Through the Rural Digital Opportunity Fund (RDOF), the FCC is directing up to $20.4 billion over 10 years to finance up to gigabit speed broadband in unserved areas. Millions of American homes and businesses will be connected with digital opportunities for the first time.

Brain drain has also been a longstanding concern in rural areas, as educated workers seek opportunities in metropolitan areas. High-speed broadband can not only keep young people in their communities but attract new people to rural areas and small towns.

As a reaction to the pandemic, families are trading city life for the open spaces and natural beauty. But they expect high-quality broadband when they get there, and in fact, their ability to continue to work remotely depends on it. An influx of high wage workers and their families can fuel growth, business activity, and build vibrant communities.

Expanding access to high-speed broadband can have a positive impact on rural electric cooperatives themselves. Without a compelling broadband offering, cooperatives risk member attrition, which impacts not only the organization itself but its anchor members—the schools,

healthcare providers, government, public safety, and local businesses that also serve their communities. Affordable, multigigabit connectivity is essential for these organizations to serve their customers and constituents.

## Building a Network for a Modern Grid

Rural electric cooperatives can address their communities' need for affordable, high-speed broadband while also leveraging a shared fiber network that supports smart grid applications and their operational technology (OT) needs. Legacy telecom networks simply won't support the next-generation applications that can increase grid performance, increase service reliability, and lower costs for co-ops.

Power grid dynamics, such as distributed energy resources, smart grid initiatives, and delivery of new services can have a profound effect on network requirements. Realizing the vision of a dynamic and stable grid requires a highly available, service-provider-grade network that supports grid applications today and in the future. The network must seamlessly interconnect with energy producers and transmission grids and enable the delivery of advanced power services to members.

Modernizing the grid network will also help rural electric cooperatives increase cybersecurity and meet North American Electric Reliability Corporation (NERC) compliance. Cybersecurity is increasingly critical as utilities deal with more regulation, cyberattack frequency, and the threat of state-sponsored attacks on critical infrastructure.

## A Vision for Community Development

Juniper Networks has teamed with industry professionals and partners with more than 20 years of knowledge to develop a proven success model for rural electric cooperatives.

Working together, our objective is to help rural electric cooperatives understand the financial feasibility and develop an effective strategy to deploy an optical fiber network to support the grid, while creating an infrastructure asset that connects anchor members in an optimized, scalable way. Communities within a co-op's service area will see economic benefits, such as job creation, training, placement, and community development.

Some cooperatives begin their broadband journey with fiber-to-the-home projects for residential members. Some of these projects have been successful, but this starting point injects a higher risk, negates potential funding operations, and misses out on economies of scale. This approach can also disquiet residential members due to implementation priority, and it typically misses the benefit yields captured when the high-speed connectivity needs of the entire cooperative service area and anchor members are considered.

At Juniper, we believe a strategic approach that simultaneously addresses the network challenges of the power grid and lays the foundation for high-speed broadband throughout a cooperative's service area will deliver lower risk and a higher value-to-cost ratio.

We have observed that a focus on delivering broadband services first to anchor members, followed by the extension of broadband into residential areas, has greater success. A fiber network that's engineered to meet the needs of anchor members in education, healthcare, public safety, local government, and business, creates a stronger foundation for community and economic development.

## Six Principles for Success

At Juniper, we recommend rural electric cooperatives follow six success principles when developing a strategy to simultaneously address the network challenges of the power grid and lay the foundation for broadband throughout the service area. These success factors lower risk and deliver a higher value-to-cost ratio.

1. **Shift from microwave to fiber connectivity**

   A fiber network that is properly engineered for a cooperative's service area will create an investment asset with a more flexible business model. Benefits include improved grid reliability, lower operational costs, increased cybersecurity, advanced interconnection to power providers, and a host of next-generation services for anchor members.

*continued from page 5*

This flexibility allows cooperatives to choose the business model that best serves their members.

Once a fiber infrastructure is in place, the wireless systems previously in operation, such as point-to-point terrestrial microwave, can be repurposed to support lower bandwidth applications.

**2. Assess the potential for services**

A modern IP network lays the foundation for a broad range of services for both rural electric cooperatives and their anchor members.

Rural electric cooperatives can leverage a modern IP network to accommodate current and future IT/business or OT/grid applications, including advanced metering infrastructure (AMI), distribution management system (DMS), outage management system (OMS), emergency management system (EMS), and teleprotection.

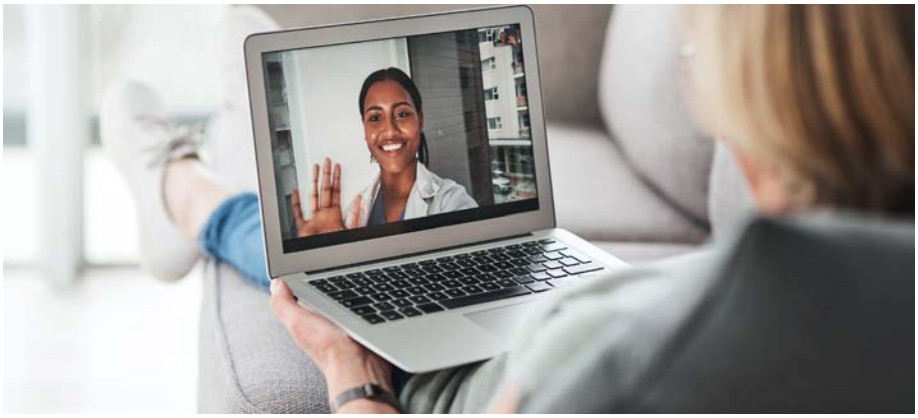
A modern fiber network supports substation video surveillance, facilities management, smart grid, supervisory control and data acquisition (SCADA), Industrial Internet of Things (IIoT) systems, and industrial cloud applications. Integrating cybersecurity into the network infrastructure strengthens protection and simplifies NERC compliance.

The benefits of high-speed broadband and smart grid are wide-ranging for the community at large:

- **K-12 schools** can support digital learning and online assessments for students who are homebound or choose remote school. Remote learning was critical during the pandemic but will continue to be essential during inclement weather and other unforeseen disruptions. State-run education service centers also rely on speedy connections to the schools they serve. K-12 schools are typically the highest concentration of facilities in a cooperative's service area.

- **Healthcare providers** can provide quality care for communities that have limited or no access to doctors or skilled specialists. Travelling long distances for medical care is commonplace. Three out of five areas federally designated as having a shortage of health professionals are rural, according to the Association of American Medical Colleges (AAMC).

  Telemedicine makes care readily available with services that include tele-psychiatry, tele-stroke, electronic intensive care unit (eICU), and prenatal care for high-risk pregnancies. High-speed connectivity enables expedited reading of X-ray and other medical scans as well as an exchange of electronic health records to deliver better patient outcomes.



- **Public safety agencies** can rely on a mission-critical network to increase collaboration and speed emergency response, including next-generation 911 services, cybersecurity protection, incident response, and severe weather notifications.

- **Local governments** can increase transparency among their constituents and civil engagements and increase the efficiency of government with greater access to digital services. Staff can leverage video collaboration and access cloud applications.

- **Businesses** can leverage videoconferencing, access cloud services, and ensure continuity of operations with connectivity to headquarters or regional offices. Rural small businesses are comparable in revenue and profit to urban businesses but currently have limited choice for business-quality connectivity.

- **Precision agriculture** requires broadband. Technology allows farming and ranching to be more efficient, economical, and environmentally friendly. Data is collected and analyzed, both locally and in remote data centers. Yet 25% of farms lack Internet access, according to the United States Department of Agriculture (USDA).

- **Residential customers** will have better digital experiences over high-speed broadband, whether they are working, learning, streaming video, or playing games. Smart home services can make their homes safer and more comfortable. Broadband enables digital access to school, healthcare, public safety, and government services.

### 3. Build a connectivity hub for "on-ramp" to high-speed connectivity

Designing the fiber network for the service area with a central access point creates an on-ramp to applications that will ultimately fill that fiber connection with value-added and revenue-generating services. Building a connectivity hub ultimately drives down the access cost for members and creates a seamless, secure access point for subscriber-based service providers and cloud applications.

A connectivity hub, which is essentially a small data center, creates an efficient on-ramp to the Internet and serves as a secure access point for service providers and users of cloud services. Designing the connectivity hub is an essential part of the assessment, design, and build phases for the service area. This hub can also serve as a cost-effective disaster recovery point between adjacent cooperatives that adopt this model.

### 4. Tap into available funding

The initial assessment and design phases of the fiber network should consider how to leverage public funding. Tapping into funding vehicles can accelerate service delivery when anchor members are identified, especially in education and healthcare.

Cooperatives should consider funding vehicles, including E-Rate Category 1, which includes the services needed to support broadband connectivity to schools and libraries.

The first phase of Rural Digital Opportunity Fund (RDOF) will target 6 million homes and businesses in census blocks that are entirely unserved by voice and broadband speeds of at least 25 Mbps/4 Mbps. Subsequent phases will cover locations that are partially served.

### 5. Consider the options for service delivery

Implementing a fiber network and on-ramp connectivity hub is foundational to the success of offering broadband and modernizing the grid network. Crafting a services delivery strategy that balances the long-term goals of the cooperatives, maximizes partnerships, and leverages local providers will yield the highest value for electric cooperatives as well as their residential and anchor members.

### 6. Develop a strategy for your service area

- Conduct a baseline assessment
- Optimize the design for the fiber plant and on-ramp hub
- Facilitate discussions with anchor members
- Develop a strategy for service delivery and operations
- Develop a project implementation and services delivery plan

# PROACTIVE GRID MONITORING: LEVERAGING FIBER OPTIC TECHNOLOGY TO RECOVER COSTS AND FUTURE-PROOF YOUR INFRASTRUCTURE

**BY: ADTRAN**

### "Storms" are always brewing...

At any moment, your infrastructure can be disrupted by a tree falling, a car accident or even vandalism. But the costs to your business don't have to be exacerbated by resource-depleting responses or one-size-doesn't-quite-fit-all truck rolls. While storm clouds on the horizon may provide some warning, smaller or less obvious issues are much more evasive. How quickly can you locate and assess a problem after your customer reports it? Better yet, can you respond to customer calls by letting them know it is already being addressed? Finally, do you have the ability to accurately determine whether a truck or a team needs to visit the scene?

Waiting on customer calls is a 20th-century scenario. Now, you have the power of industry-leading technology — fiber optic technology. And if you're wondering whether this is only beneficial for internet service providers, think again. Fiber optic technology offers more than fast Wi-Fi. It enables you to monitor your infrastructure end-to-end, be it fiber broadband networks or power grids. Metering and substation technology offer some information, but can you harness all these disparate data points into a unified, holistic view? Most importantly, are you able to recover costs with your current technology?

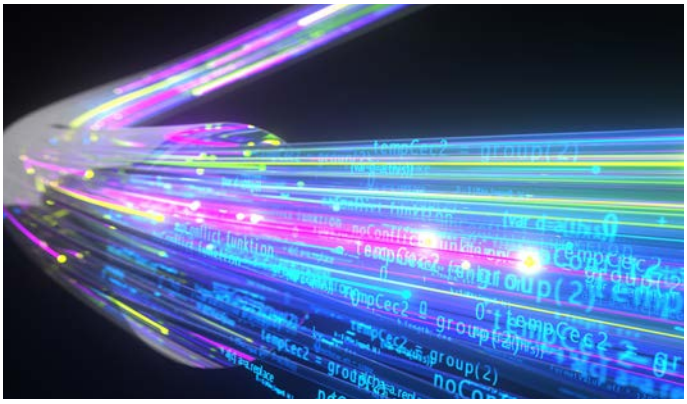
### Revenue-depleting culprits:

- Costly reactive responses
  - Not knowing about problems before customers call
  - Wasting time locating the problem
  - Wasting resources by assessing the nature of the problem on-scene
  - Inefficient resource allocation and timing, leading to lost revenue and increased operational costs
  - Reduced revenue over time due to reliance on reactive solutions
- Siloed communications
  - Separation of information
  - No aggregate solution for various data points; including metering, reclosers, substations, etc.

- Bandwidth constraints
  - LTE cards that cannot meet demand
- Critical communications and monitoring
  - Power delivery needs resilient, real-time communications
  - Inability to be proactive without sufficient or real-time communications
  - Inability to quickly assess issues and roll out appropriate resources

## A worthy investment

Fiber optic technology like Adtran's not only empowers operators to modernize and leverage unified insights, but it also ultimately leads to cost recovery and resource protection. Over time, this investment brings quantifiable returns to operators.



## Dollar impacts:

- Real-time monitoring maximizes customer experience by enabling speed and efficiency
- Operators are better able to allocate the right kind and right amount of resources
- Search time is eliminated as resources can now be sent to exactly the right location

Adtran's fiber monitoring solutions provide comprehensive insights into the health of your grid. While you may already know the power usage and status at your substations, leveraging fiber technology can dramatically enhance your infrastructure view into a more holistic one. Now, you can better manage your grid, your resources, and your revenues.

## You have two key advantages… Harnessing your existing expertise and federal grants

You've already built a community. For years, you've served homes and businesses and held together the foundation of modern society. But beyond lighting your neighborhoods and storefronts, you have the ability to offer your customers reliable internet access. Fiber can help you ensure the reliability of your power grids, but it can also deliver leading internet access and network monitoring.

One of the most important aspects of a fiber build is knowing where it's needed most. This is your leg-up – the blueprints to light up the town, the existing structure of your neighborhoods, campuses and businesses.

Additionally, there is currently an unprecedented amount of grant funding available to providers nationwide intended to expand communications infrastructure unlike anything seen in decades and unlikely to recur for years to come. With partner programs like Adtran's, you can receive valuable assistance in the grant application process and maximize the effectiveness of your funding. This presents a unique opportunity to leverage your relationships and expand your resource pool, ultimately leading to an enhanced customer experience and a resilient revenue stream.

You have the power to leverage 21st-century innovation today. With Adtran, you can offer end-to-end services to your community and protect your infrastructure for decades to come.

# EMPOWERING UTILITIES WITH BETTER COMMUNICATION

## Seamless operations with secure networking and resilient timing

**BY: ADVA**

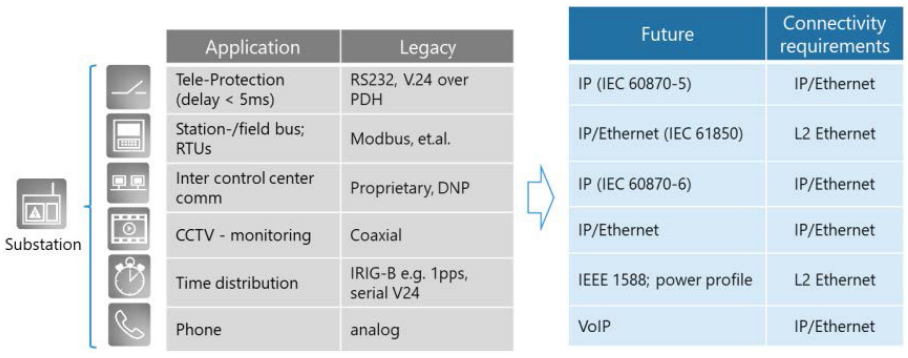
Wide area networks have always been critical to energy companies. But the solutions applied today might not be sufficient for the demands of the future as legacy technologies become obsolete and new protocols must be supported. The digital transformation is also impacting networking technologies and forcing a convergence to IP and Ethernet. What's more, with distributed energy production, there is a need to push advanced control technologies from core to edge. This extends the coverage of the wide area network, but also requires precise synchronization to be delivered to remote sites in the power grid. The migration of the wide area network is a highly complex task, which becomes even more complex with the changing threat landscape and the increasing number of sophisticated attacks.

This article highlights proven methods for converging legacy communication networks and making them future-proof and secure.

It explains the relevance of resilient, accurate timing and shares best practices for robust synchronization networks. It also highlights some solutions from ADVA that can help you make the transition.

### Towards a future-proof WAN architecture

Historically, energy companies have installed a variety of application-specific solutions. Supervisory control and data acquisition (SCADA) systems, industrial control systems (ICS), solutions for tele-protection, and intra-office systems use specific communication protocols. Proprietary protocols and purpose-built hardware have successfully worked in the past, but this approach will not meet future needs. Figure 1 outlines the technology convergence as it happens in power grids today.




| Application | Legacy |
|---|---|
| Tele-Protection (delay < 5ms) | RS232, V.24 over PDH |
| Station-/field bus; RTUs | Modbus, et.al. |
| Inter control center comm | Proprietary, DNP |
| CCTV - monitoring | Coaxial |
| Time distribution | IRIG-B e.g. 1pps, serial V24 |
| Phone | analog |

| Future | Connectivity requirements |
|---|---|
| IP (IEC 60870-5) | IP/Ethernet |
| IP/Ethernet (IEC 61850) | L2 Ethernet |
| IP (IEC 60870-6) | IP/Ethernet |
| IP/Ethernet | IP/Ethernet |
| IEEE 1588; power profile | L2 Ethernet |
| VoIP | IP/Ethernet |

*Figure 1: Digital transformation of power grids*

While SDH/PDH technology is still used in the power utility WAN, many operators have complemented, or substituted, those legacy networks with IP and MPLS technology. In many cases, MPLS-TP is being applied as this specific flavor of MPLS uses centralized provisioning of label-switched paths, and is operationally aligned with SDH/PDH networks, simplifying its introduction and adoption.

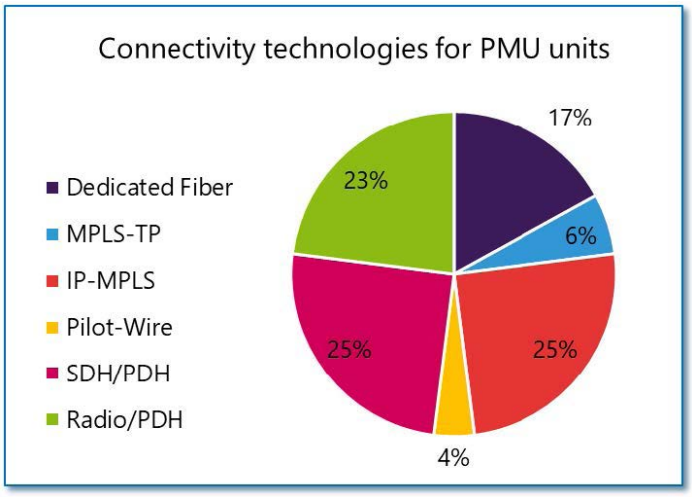



***Figure 2: Connectivity technologies for phasor measurement units (PMU)***

The International Council on Large Electric Systems (CIGRE) Study Committee D2, December 2021 recently performed a survey on the current state of telecommunications in power utilities. The results shown in Figure 2 give a good insight into the state of migration from TDM to packet:

While roughly a third of this traffic is transported over MPLS, there is still a large proportion using legacy technologies.

Technology migration happens gradually. A connectivity network will need to transport legacy TDM but also MPLS traffic. MPLS-TP may be used for a tactical smooth transition from TDM to packet network technologies. However, as it isn't widely supported by suppliers and it is getting competition from segment routing, this technology is unlikely to continue. Segment routing combines the best of IP and MPLS while including TP management practices.

Vertically integrated solutions are difficult to migrate and align with changing requirements such as MPLS technology evolution. In consequence, we should architect networks in a disaggregated and open way with the possibility to select best-in-class technology for MPLS and DWDM transport. As shown in Figure 3, open optical transport technology can easily be combined with hybrid TDM/packet technologies such as those from our partner OTN Systems or a pure-play ADVA FSP 150-XG400 packet solution.

Secure transport in the WAN is essential for protecting critical infrastructure from cyberattacks.

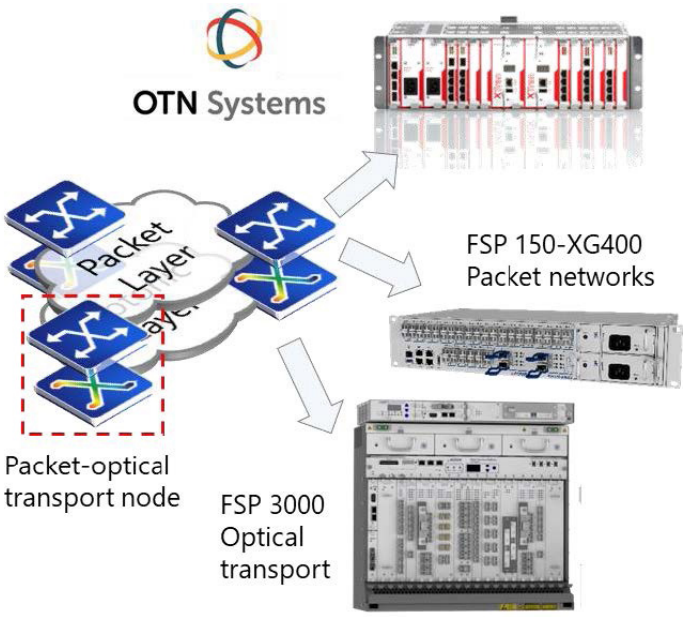



***Figure 3: Disaggregated design of the WAN***

In many countries, regulatory obligations require the encryption of mission-critical communication to assure business continuity. The packet network and optical network devices should be able to encrypt network traffic at line rate. Our FSP 3000 open optical transport platform supports line-rate encryption of wavelengths while MACsec+ provides end-to-end encryption at the FSP 150 packet layer.

Failures of network components or fiber breaks cannot be avoided, but the impact can be minimized with resilient and well monitored networks.

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Protection mechanisms such as optical path protection, Ethernet ring protection or redundant MPLS paths can instantly repair network failures in an automated way. However, it is still necessary to identify the failed component and initiate immediate repair. This is done through sophisticated OAM capabilities at the optical, Ethernet and IP/MPLS layer.

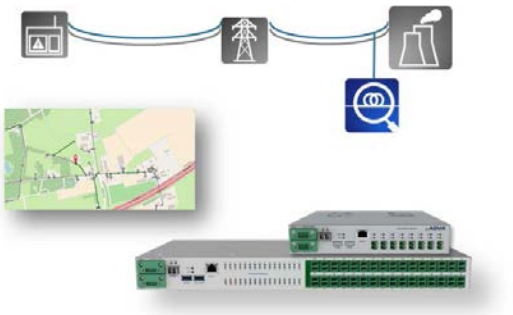


*Figure 4: Fiber monitoring for immediate failure detection and localization*

A failure in the passive fiber network can be detected and localized within milliseconds with the help of OTDR-based fiber monitoring solutions. What's more, with the help of fiber sensors for security and environment applications, any threat to the physical infrastructure can be instantly detected.

## Protecting sub-stations from cyber threats

With the emergence of distributed power generation, automated control is moving from primary to secondary substations and towards decentralized solar power plants and wind farms. Distributed power generation creates a need for visibility and control of a high number of remote energy production sites.

As operational technology (OT) is moving to the edge of the power grid, standardized and innovative solutions will be applied, converging the previously applied operational protocols on a common IP and Ethernet transport layer.

The digital transformation at the substation will not happen with a forklift upgrade but in a seamless migration, leveraging proven technologies and migrating towards a converged IEC 61850 automated substation architecture. During this transition period, a diverse set of technologies will need to be supported at substations. Established asynchronous and synchronous interfaces such as RS232 or STM1 or application-specific interfaces such as C37.94 for tele-protection will be applied while TDM network interfaces migrate to Ethernet over DWDM.

Most legacy technologies have not been designed with security in mind. In some cases, operating systems are now reaching end-of-life and are suffering from a lack of security patches. This results in the need for a security architecture at a substation which prevents vulnerable components and sub-systems from any access.

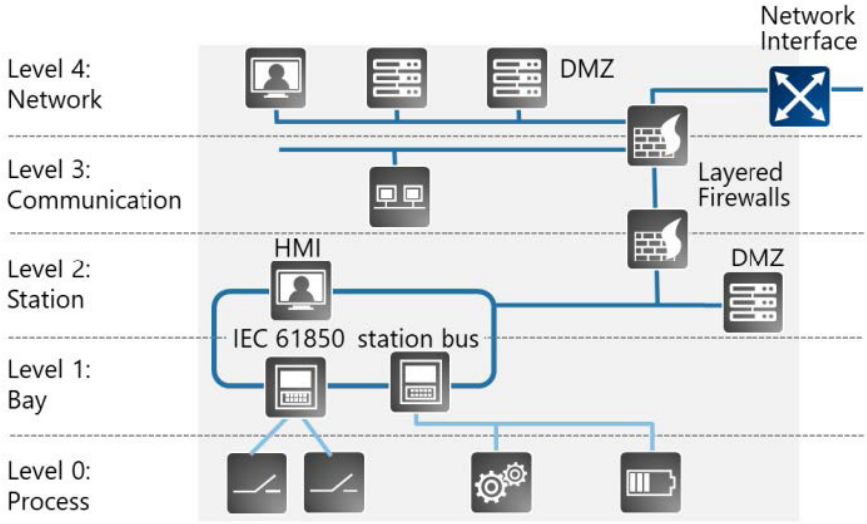



*Figure 5: IEC 62443 cybersecurity architecture for industrial control systems*

With IEC 62443 a comprehensive framework is available, guiding the implementation of cybersecurity in industrial control systems (ICS). Based on a risk assessment, it specifies a zoned architecture to protect the most critical assets with multiple layers of defense.

National regulators are also requesting critical infrastructure to implement controls for assuring business continuity. This makes general security controls such as encryption of the connectivity network, firewalls, and intrusion detection systems a requirement.

In Germany, for instance, the Information Security Act 2.0 creates a need to identify and report attacks to critical infrastructure. This isn't an easy task, as present substation applications do not provide an easy way to do this.

ADVA is responding to this need with a softwarecentric security solution, optionally supported by a secure and environmentally hardened edge compute node. Monitoring of ICS/SCADA traffic can be done most efficiently by software probes. Several suppliers provide the appropriate software applications, but they do need to run in a protected, security-hardened environment.

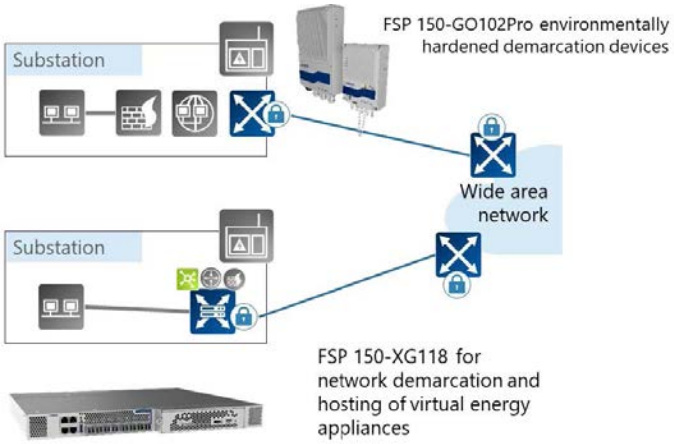



*Figure 6: Securely connecting substations with the wide area network*

Ensemble Connector is a hosting platform and network operating system with comprehensive protective controls. It can be installed on an FSP 150-XG118 (CSH), which is an edge compute node featuring advanced encryption for securely connecting a substation to other sites of the power grid. Ensemble Connector can also be installed on x86 based COTS servers; for utility use cases the servers will need the appropriate security features.

ADVA is working with leading suppliers of software for monitoring substation traffic such as Nozomi or Palo Alto to identify any malicious activities targeting both the IT and OT network.

## Making synchronization networks robust and secure

Synchronization and timing have been a requirement for the PDH/SDH communication network in the past. Many protocols applied at substations such as DNP or GOOSE require timing, but only with moderate millisecond accuracy. With the IEC 61850 substation automation standard and technologies for precise localization of network faults, sub-microsecond timing will need to be assured. While frequency synchronization is delivered from the connectivity network by means of SyncE, time of day (ToD) information is frequently provided by Global Navigation Satellite Systems (GNSS), such as GPS, located at each and every site.

In consequence, many power utilities apply a high number of GNSS receivers at their substations for access to precise time. There are growing concerns about disturbances caused by jamming and spoofing attacks, solar events, weather patterns, etc. The operational complexity of thousands of GNSS receivers also adds considerable cost. What's more, these receivers are often not integrated into central management systems. Consequently, problems, failures and attacks against timing networks at substations might pass unnoticed until major failures in the power grid occur.

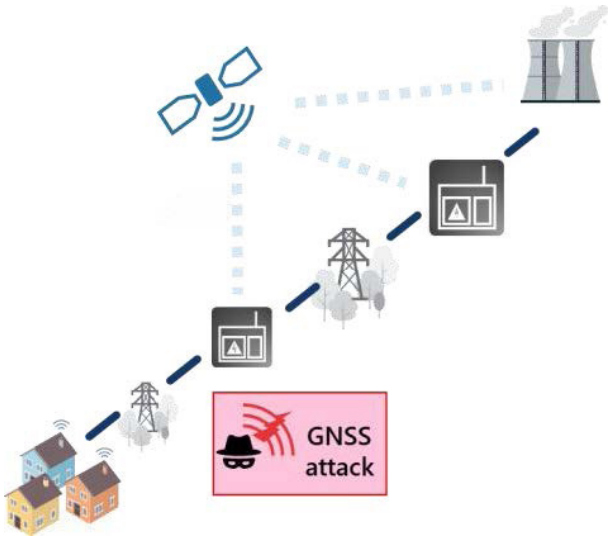



*Figure 7: GNSS attacks threaten business continuity*

*continued from page 13*

There is an urgent need for a highly resilient and accurate synchronization architecture in power utilities. Delivering accurate synchronization with the packet network is a sensible approach to initially backup GNSS-delivered timing and eventually become the main timing source. This requires timing-aware switches and routers supporting SyncE and PTP in combination with highly stable core grandmasters backed up with ultra-stable cesium atomic clocks to meet even the most stringent enhanced primary reference time clock (ePRTC) specifications.

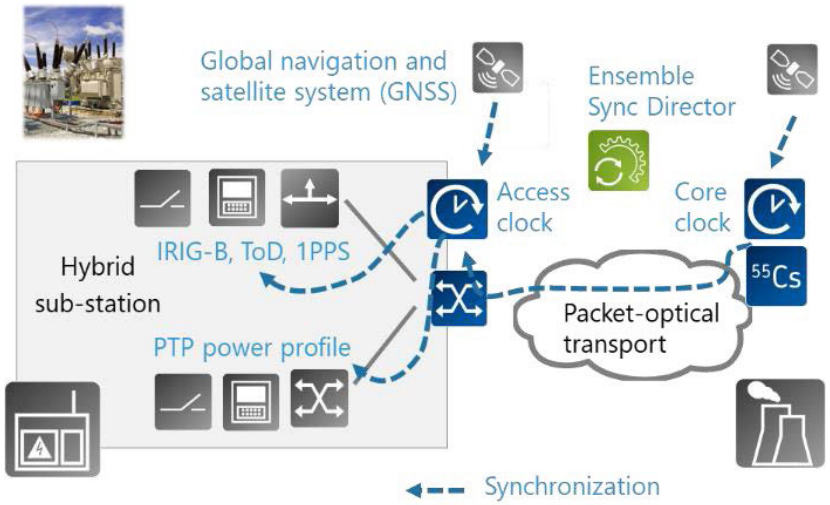



***Figure 8: Providing accurate and resilient substation timing***

As mentioned before, multiple protocols need to be supported at substations. This is also true for the synchronization network, which needs to support legacy interfaces such as IRIG-B at substations or NTP.

ADVA's Oscilloquartz division provides the most comprehensive assured positioning, navigation, and timing (aPNT+™) technology for resilient power grid timing. With multi-technology substation grandmasters, modular and redundant core grandmasters in combination with proven, ultrastable cesium clocks, this comprehensive solution portfolio can be adapted to any power grid timing need. What's more, the unique AI-empowered Ensemble Sync Director management solution assures accuracy of timing at any site, even analyzing data from any third-party GNSS receiver.

## Technology experts are joining forces

Communication networks for power utilities are covering applications in very different competence domains. There are IT applications that need standard IP connectivity over fixed and wireless networks but also utility OT applications such as SCADA and tele-protections with domain-specific protocols and interfaces. Suppliers with OT experience and products will work with suppliers addressing the IT and service provider market in order to combine their solutions and meet both current and future communication requirements.

This is why OTN and ADVA have joined forces to pre-integrate and test a network solution for power utilities. Both companies have a leading portfolio in their home markets, and their combined solution perfectly meets the most demanding communication requirements of critical infrastructures.

OTN Systems provides a market-leading network solution for specific industrial segments, including public networks, light rail, oil and gas, power utilities and mining. With its new product line, XTran, the company is well positioned to offer market-leading solutions to those enterprises.

What's more, ADVA is joining forces with independent software vendors providing software applications at the substation to monitor and protect the IT and OT network.

Jointly with our partners, ADVA offers a comprehensive, secure and resilient wide area network for power utilities, featuring accurate and robust synchronization and supported by a powerful end-to-end management system.

## The ADVA solution for wide area networks

ADVA's carrier-grade network products are a perfect solution for communication networks with power utilities, combining operational simplicity with high availability and resilient designs. In addition, ADVA offers infrastructure assurance solutions for passive , in-service monitoring of fiber and sites. Oscilloquartz, a fully owned ADVA company, is a market-leading supplier of synchronization solutions. Its portfolio was recently extended with PTP power profile, NTP server and IRIG-B interfaces for seamless migration of legacy synchronization solutions towards highly accurate PTP technology. ADVA's unique aPNT+ platform has been specifically designed and optimized for robust, secure and resilient timing for critical infrastructure.

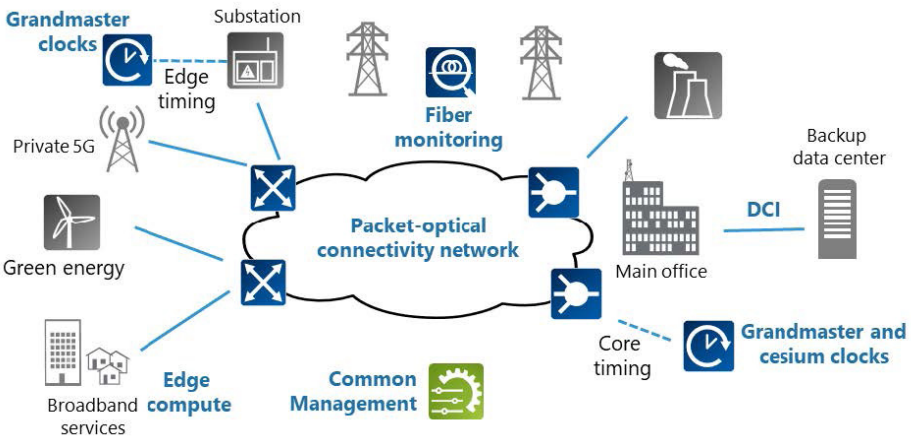



*Figure 9: ADVA solution overview for power grids*

The wide area networks of power utilities combine DWDM transport with IP routing and Ethernet, as well as MPLS switching. Disaggregated architectures create flexibility and simplify the complex migration from today's architecture to next-generation power grid networks.

However, this does create the need for a strong management system to integrate all components with central control. ADVA's Ensemble Controller provides comprehensive end-to-end management for the packet, optical, virtualization and synchronization network.

While the digital transformation of IT and OT networks is making network operations robust and future proof, it is a very complex undertaking. Operators will move carefully and will initially focus on those components with the most significant need for action. We believe that the synchronization and timing network is an area of underestimated risk; the threat landscape is changing rapidly as nation state actors engage. In addition, component obsolescence or shortage due to the silicon crisis is triggering a transition to open, multi-vendor technologies with unique benefits but also transformational challenges. ADVA is an experienced supplier of market leading communication solutions that understands what is needed to operate a network. We can be your reliable partner for making communication networks secure, resilient, and future proof.

# BROADBAND FOR EVERYONE: KEY CONSIDERATIONS FOR BUILDOUT

**BY: CRAIG CULWELL**
**COMMSCOPE**

Broadband has become an essential utility for people around the world. It powers the digital economy; it makes applications such as remote learning and telemedicine possible; and it sets the stage for a future where virtual reality, augmented reality, and the metaverse are commonplace. Unfortunately, true broadband is still out of reach for many.

According to the U.S. Department of Commerce and the NTIA, 22.5% of U.S. households are estimated to not have access or the ability to purchase broadband internet. Furthermore, 17.3% of rural households and 1.2% of urban households lack fixed terrestrial access to speeds greater than 25 megabits per second (Mbps) for download and 3 Mbps for upload, which is considered to be unserved according to the FCC's Broadband Deployment Report.

In support of closing this digital divide, governments and municipalities have introduced initiatives that provide billions in funding to build out broadband networks and bring high-quality connectivity to all, especially low-income neighborhoods and rural communities. In the U.S., these programs include:

- The Rural Digital Opportunity Fund (RDOF)
- The Consolidated Appropriations Act, 2021 (CAA)
- The Coronavirus Aid, Relief, and Economic Security Act (CARES)
- The Infrastructure Investment and Jobs Act (IIJA)
- The American Rescue Plan Act of 2021 (ARPA)

Even with money flowing into the broadband buildout, there are still plenty of challenges to overcome and issues to consider. In this article, we'll discuss some key considerations that may help with your network planning.

## Understanding density's impact on fiber installation costs

Population density, i.e. homes per square mile, typically comes to mind as a key metric in calculating the return on investment potential for fiber broadband buildouts. But for service providers targeting rural markets, homes per linear mile is a much more useful measurement. That's because rural broadband networks typically follow the long roads between homes, and the lengths of those spans are key drivers of both material and labor costs. Densities below eight homes per linear mile require special consideration since they create the greatest delta between infrastructure costs and revenue opportunities.

## Choosing the right broadband technology

Delivering broadband to everyone, everywhere requires service providers to evaluate a mix of technologies leading with fiber to

the home (FTTH) due to its future-proof capabilities. Service providers are also evaluating fixed wireless access (FWA) and, in some cases, low earth orbit (LEO) satellite technologies, which can be deployed relatively quickly but can be limited in their ability to meet long-term capacity needs. The right choice for a given geography or application will come down to the important dynamics of bandwidth, economics, and homes per linear mile. While it may not be perfect for every geography or application, expect FTTH to play a key role in most broadband buildouts due to its capacity, scalability and expected lifespan.

## Considering PON's distance thresholds

Passive optical network (PON) technology, the leading choice for FTTH deployments, has a distance threshold between the optical line terminal (OLT) and the last optical network unit (ONU). Therefore, it may not seem practical for rural locations with significant distances between central office facilities and subscriber homes. But new remote OLT solutions can extend PON's launch point deeper into the network and allow even the most remote subscribers to take advantage of high-quality broadband. This makes FTTH an option in locations where it was once impractical.

## Navigating a constrained labor market

The pool of skilled labor for network, cable and field technicians is already stretched thin in the telecommunications services market. As broadband for everyone marches on and service providers build out new network facilities and connect new subscribers, the labor shortage is expected to grow. While training will help fill in the labor and skills gap, now is the time to consider technologies that simplify fiber installation, hardware provisioning, troubleshooting and repair to maximize the skilled labor resources we have in the broadband industry.

## Easing operational expenses

Even though FTTH technology is easier to maintain compared to other alternatives, the management and maintenance of fiber networks can create significant work—and significant costs. That's why it's important to consider the expenses of provisioning services, upgrading networks, finding issues, and fixing problems. In rural markets, where technicians often need to travel long distances to upgrade, maintain, troubleshoot, and repair the network, small savings can add up fast.

## Deploying fiber faster

Broadband for everyone may not happen overnight, but it will likely happen fast thanks to the perfect storm of exploding bandwidth demand and significant new funding. For service providers, seizing this opportunity begins by getting educated on the process of securing grant funding right away—and extends all the way to getting new fiber networks and segments built out as quickly as possible.

By moving fast, service providers can connect subscribers to their networks in the near term, while helping to stave off competition and expediting their returns on fiber investments.

## Broadband for everyone starts now

While broadband for everyone is an ambitious goal, it is achievable. One of the first steps of the journey is for service providers to recognize the challenges, opportunities, and economic realities of network deployment in underserved markets. The CommScope team is committed to examining these issues in detail as our broadband for everyone campaign continues.


# IPv6 — ARE WE THERE YET?

## How to Navigate the On-going Transition from IPv4

**BY: TERRY YOUNG**
**DIRECTOR OF SERVICE PROVIDER NETWORKS**
**A10 NETWORKS**

Regional internet service providers (ISPs) including, wireless and wireline/FTTH operators, electric cooperatives and municipalities have long played a vital role in supplying critical power and connectivity to rural and remote communities. Today, 260 telephone and 834 electric cooperatives serve much of rural America[1], which includes just 14 percent of the population, but 72 percent of the land area.[2] Now these diverse regional ISPs are poised to play a crucial role in connecting the remaining unserved communities and some 23-42 million homes.

This is a unique opportunity to do far more than just enable unserved communities to catch up to the high-speed broadband taken for granted in densely populated urban areas. By fully leveraging new government funding, increased public interest, and recent digital adoption gains, regional ISPs can help these communities leap ahead in digital adoption, providing them new capabilities that are absent in high-tech urban areas with older infrastructure.

Digital divide programs like the FCC's Rural Development Opportunity Fund (RDOF), Emergency Broadband Benefit Program, Connect America Fund, and the USDA's ReConnect, and more recently the Infrastructure Investment and Jobs Act have made billions of dollars available to help bridge the digital divide. Regional ISPs now have a wealth of opportunities to add subs, build out to new areas, and grow their business. First, though, they'll need to address the challenges posed by IPv4 exhaustion—and its impact on the cost of new subscriber IP addresses.

Leaping ahead will require a focus on the network end-do-end – not just on the critical last-mile access – but also to the supporting core network technologies and systems that strengthen the overall digital resiliency and security of their network, while meeting rising subscriber expectations. A more comprehensive approach will result in new subscribers served by a network that is fully carrier-grade, end-to-end.

One critical core technology that regional ISPs often initially overlook is carrier grade networking – the technology that manages scarce IPv4 addresses and provides a path to IPv6 adoption.

### What's Happening to IPv4?

Every internet-connected home or business requires an IP address. IPv4 addresses, using the original

addressing scheme protocol, were fully allocated by the regional IRRs years ago. IPv6, the replacement protocol, provides near limitless address space, but has faced uneven adoption and operational roadblocks. Today, despite 20 years of heavy industry promotion, IPv6 has still not fully replaced IPv4. About two-thirds of subscriber internet sessions and 80 percent of websites are IPv4 only and do not support IPv6.[3] In addition, many applications, security devices and other network equipment do not fully support IPv6.

For regional service providers, who must provide connectivity for everyone to everywhere, that means they must support both protocols in their networks for years to come.

IPv4 addresses have become a scarce resource and as a result, the price through private brokers has skyrocketed up to $60 each earlier this year. Large hyperscalers such as AWS, Tencent, Alibaba and others are buying up IPv4 addresses through brokers to create competitive advantage and ensure that their enterprise users of their cloud services always have adequate IPv4 options. AWS, for example, is estimated to control over 100M IPv4 addresses. Organizations, including universities, large corporations, tier one mobile and fixed network operators, and regional service providers, are "selling" their excess IPv4 addresses at market price and using the funds for other infrastructure projects.

## The ISP IPv4 Dilemma – Should I stay, or should I go?

The regional ISPs that received an original allocation of "free" IPv4 addresses from ARIN years ago, have built their initial network using IPv4, simply dedicating a public IP to every subscriber/household served or by using basic NAT to direct IPv6 traffic. Now facing significant subscriber growth through new buildouts, they must make a technology decision to either acquire additional IPv4 addresses at significant cost (but preserving the existing network architecture) or make other fundamental changes in the network architecture to include carrier grade NAT (CGNAT), IPv4-IPv6 transition, and other needed upgrades.

The alternative to IPv4 exhaustion and acquiring more IPv4 addresses is, of course, to use the newer standard, IPv6. IPv4 exhaustion has been an industry topic for over 20 years. Tier 1 service providers that have already addressed the technical complexities through a combination of CGNAT, dual-stack and IPv4-IPv6 transition strategies. However, for smaller ISPs with limited budget, resources and no prior opportunity for significant subscriber growth, the influx of significant government funding may be the first opportunity they have had to reassess and upgrade their core network, including the capacity of their existing IPv4 address pools and a plan to eventually transition to IPv6.

Often smaller organizations simply cannot justify the near-term cost and disruption that a full network change-out for IPv6 migration will entail. Full IPv6 adoption is costly and time consuming. The IT admin must inventory all connected devices and change out or reconfigure them. There is a risk that a needed device or application will not work and will cause service disruption that will take time to troubleshoot and fix. Older customer equipment may not be compatible with IPv6, and the replacement cost is too high. Balanced against the daily operational demands they face, as well as the need to move forward on strategic initiatives like 5G, cloud, virtualization, edge cloud, and others, administrators may need to delay IPv6 conversion in the short term.


A robust carrier grade networking technology, such as offered by A10 networks can provide an interim solution, by both preserving the limited IPv4 address pools and providing a smooth transition mechanism to IPv6.

*continued from page 19*

## What is CGNAT?

Carrier grade NAT (CGNAT), a standard for network address translation (NAT), makes it possible to extend the life of existing IPv4 addresses to support additional subscribers.

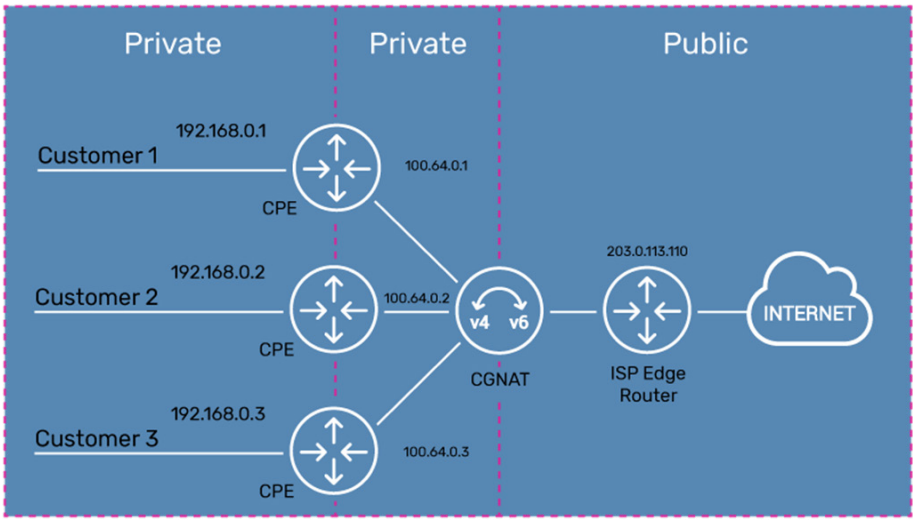
While standard NAT translates a private IPv4 address to public IPv4 address, Carrier Grade NAT (CGNAT) adds an additional translation layer. This allows ISPs to preserve their own public IPv4 addresses, process subscriber traffic through the service provider's private IPv4 network and support subscribers or businesses that also have their own private IPv4 networks, and multiple locations or devices. Typically, service providers use Carrier Grade NAT (CGNAT) in a NAT 444 scenario, which translates:

- (Customer) Private IPv4 to (ISP) Private IPv4 network address
- (ISP) Private IPv4 network address to (ISP) Public IPv4 network address, for connection to the internet

The result of a NAT444 (private to private to public) deployment is that it allows multiple customer networks with their own internal network address space to route through the ISP's internal network address space and share the ISPs single public Internet IPv4 address for access to the Internet. In a residential scenario, NAT444 allows a home router to support multiple home devices and for the ISP to support multiple home devices or subscribers with a single IP address.

With CGNAT, a single IPv4 address can support multiple endpoints (subscribers/homes). The most common oversubscription ratio is 64:1 for wireline operators but can be even higher. Thus, a single /24 (256 IPv4 addresses) can support 16,384 subscribers or more. If an ISP should decide to "sell" their excess IPv4 addresses, at the peak price of $60 each, one unused /24 block could bring in over $15,000 (minus broker fees). Market prices for IPv4 address vary by region, by block size and other market conditions.

In 2021, the open market "price" of an IPv4 address in a 256-address block (/24) in North America, jumped from a low of $25 each in January to a high of $60 in late November. The price in the first four months of 2022 has hovered between $50 - $55. What would be the expected price for an ISP looking to acquire more IPv4 addresses to sustain growth in the next few years? Will that high growth in price continue for the next five years or has it now "topped out" and will increase only marginally.




Using CGNAT, regional ISPs can capture new opportunities for growth—while simultaneously positioning their business for IPv6 migration when the time is right. This topic is explored in depth in the eBook, "IPv6 – Are We There Yet? How to Co-exist with IPv4 and IPv6 using CGNAT."

## IPv4-IPv6 Transition Technologies

The IETF introduced IPv6 as a draft standard in December 1998 to solve the IPv4 exhaustion problem and fully ratified it in July 2017. Since its introduction, globally IPv6 adoption has progressively increased across devices, service provider networks, and content providers, but with quite a bit of geographic differences by country.

However, there are still large numbers of websites, devices and networks that are primarily IPv4 and most service providers, education institutions and enterprise must support connectivity between both IPv4 and IPv6 for their users and subscribers, even when their own networks have been fully migrated to IPv6. As a result of this hybrid environment, technologies have emerged that help this transition process and enables connectivity between IPv4 and IPv6 devices, networks, and Internet destinations. These technologies either translate between IPv4 and IPv6 addresses or encapsulate traffic to enable passage through the incompatible network. These technologies include:

- NAT64, DNS64
- DS-Lite
- 464XLAT
- Lw4o6, MAP-T, MAP-E
- 6rd

These address and protocol translation techniques available allow a subscriber to transparently access content regardless of the protocol stack their device is using, the provider's access and core network support for IPv4/IPv6, and the destination server support. Tunneling techniques, such as DS-Lite, encapsulate IPv4 packets over an IPv6 access network, while IPv6 Rapid Deployment (6rd) encapsulates IPv6 packets over an IPv4 access network. Native protocol translation techniques, such as NAT64 or NAT46, translate between the protocol stacks at a gateway within the provider's network when the subscriber and provider networks natively support either IPv4 or IPv6.

## IPv4 and IPv6 will Co-exist for Years

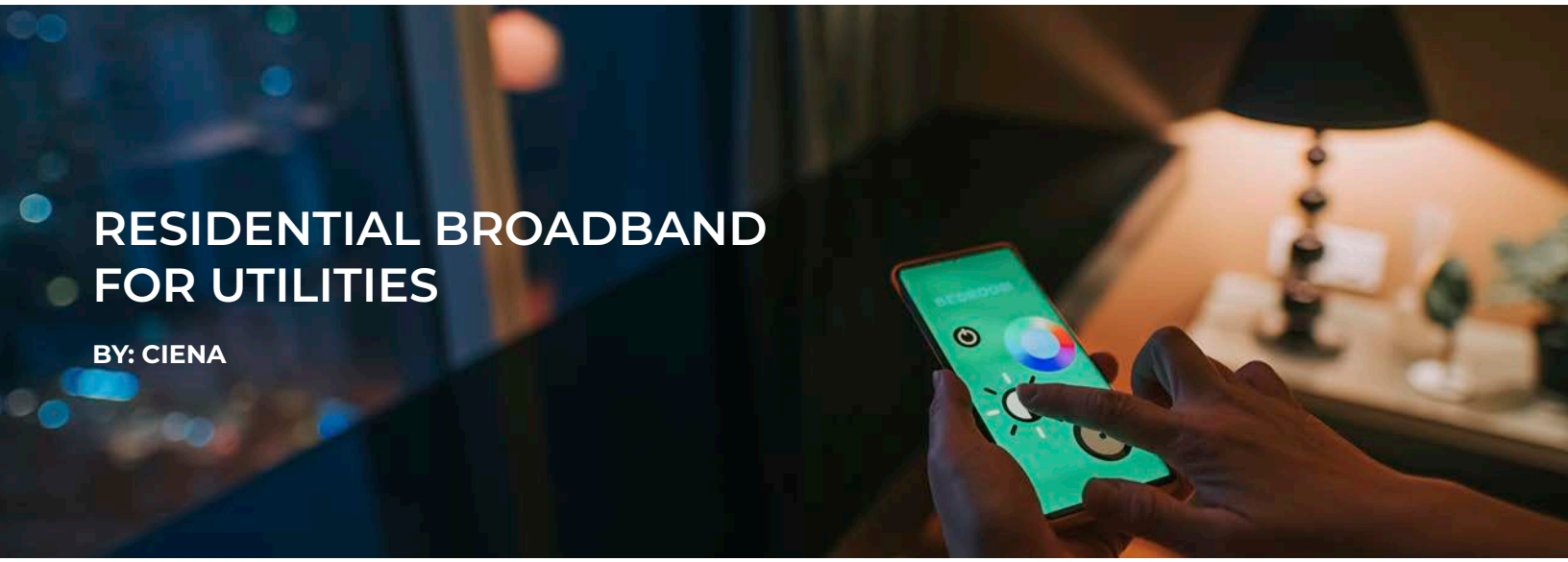
Globally, IPv6 adoption will not be achieved overnight. To provide a complete IPv6 service, each link in the chain must be running IPv6, from the end user to the carrier to the content provider. Realistically, not all three of these links in the IPv6 chain will transition to IPv6 at the same time. IPv6 will likely never reach 100 percent adoption. Therefore, most organizations, including communications service providers of all technologies and sizes, will need to support both IPv4 and IPv6 for traffic and subscribers for a long time.

Service providers will need to address upfront the challenges posed by IPv4 exhaustion, IPv6 adoption and IPv6 migration, and its impact on the cost for addition of new subscribers. Service providers need to implement CGNAT wisely — addressing the immediate challenge of IPv4 exhaustion while making plans for an eventual transition to IPv6.

[1] Cooperatives Fiberize Rural America: A Trusted Model for The Internet Era

[2] USDA Economic Research Services defines rural as the total population of nonmetro counties

[3] A10 Networks, "Making Cents of IPv4"



# RESIDENTIAL BROADBAND FOR UTILITIES

**BY: CIENA**

Broadband service deployment in rural communities has been limited, as it is difficult for legacy providers to justify a business case for broadband in sparsely populated areas. Consequently, the lack of adequate bandwidth for broadband presents a challenge to rural residents—from unreliable work, retail, and entertainment services to unavailable critical healthcare and advanced education services. COVID-19 has only accelerated these trends, cementing high-speed, reliable broadband as an essential service rather than a luxury, no different than other essential utilities that are taken for granted like electricity, gas, or water.

Rural utilities are in the unique position of having physical infrastructure in place for electric power that can be leveraged to bridge the digital divide. But their core business remains the supply of electrical power, which needs to be delivered more cost-effectively and with fewer staff covering multiple roles. This fuels the need to emulate larger utilities in modernizing their power grid—along with automating their operations and billing—with initiatives such as the deployment of smart meters. The shift towards renewable energy generation, the growth in smart devices in homes, and the expanding electric vehicle ecosystem all create further challenges that place more strain on communications solutions for utilities.

Managing the significantly increased volume of broadband traffic—while allowing critical teleprotection traffic to be prioritized—demands a converged network for both residential broadband and smart grid services that spans both the last mile and the middle mile. This is a key factor when considering investing in a network— can it address the operational challenges of the core utility and deliver rural broadband to the communities it serves.

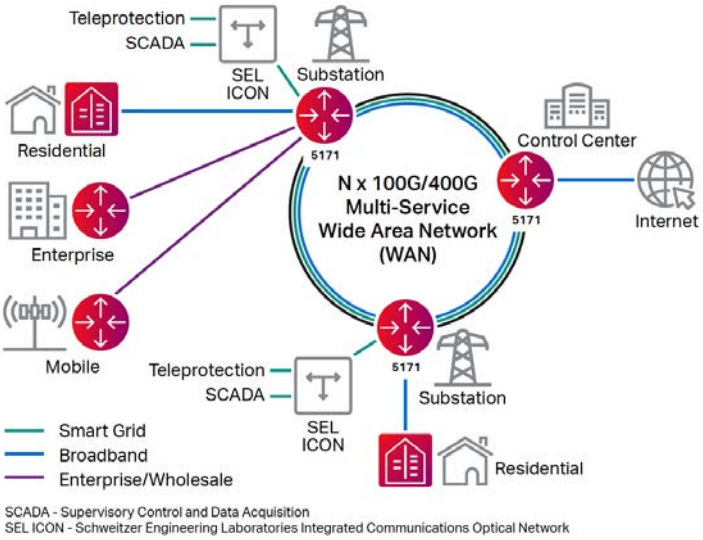



*Figure 1: Converged residential broadband/smart grid network for utilities*

## How is broadband becoming an essential service?

COVID-19 caused a major change in internet consumer patterns. The move to working from home—both for employed adults and students in schools, colleges, or universities—has dramatically increased the use of collaboration applications such as Zoom and Microsoft Teams, causing an exponential growth in internet traffic. And while some schools and offices have reopened, a significant portion of the home-working trend is becoming permanent. The move to remote working and learning, as well as the massive uptick in entertainment streaming services such as Netflix and Hulu, has led to an overnight shift in internet traffic consumption.

Despite the rise in traffic levels, traditional service providers' metro networks coped well, and connectivity for consumers and businesses in urban areas remains a well-served market. Yet rural areas were already lagging even before COVID-19 in terms of broadband network reach, access speeds, and cost. Despite government incentives, it is difficult for legacy service providers to justify the capital investment across the more dispersed population that characterizes rural broadband. But high-speed broadband is essential for people living in these locations. The need for reliable broadband is now a fundamental part of their working and recreational lives—no different than electricity was over 90 years ago.

## The multi-service opportunity for rural utilities

Utilities have an existing business justification for investment in high-capacity packet-optical transport between their substations to carry traditional Operational Technology (OT) traffic. Smart grid also impacts a utility's substation OT services, such as teleprotection for power lines which enables faster and more widespread monitoring and control at substations so the network can respond to failures with corrective action. All the while, the modernized network must continue to support, secure, prioritize, and deliver ultra-low delay connectivity for these essential mission-critical services. It makes sense for utilities to leverage this smart grid infrastructure to aggregate internet traffic from broadband services to meet the needs of their new residential and business customers. Not only does it create a new revenue stream, but also provides an essential service for their rural communities.

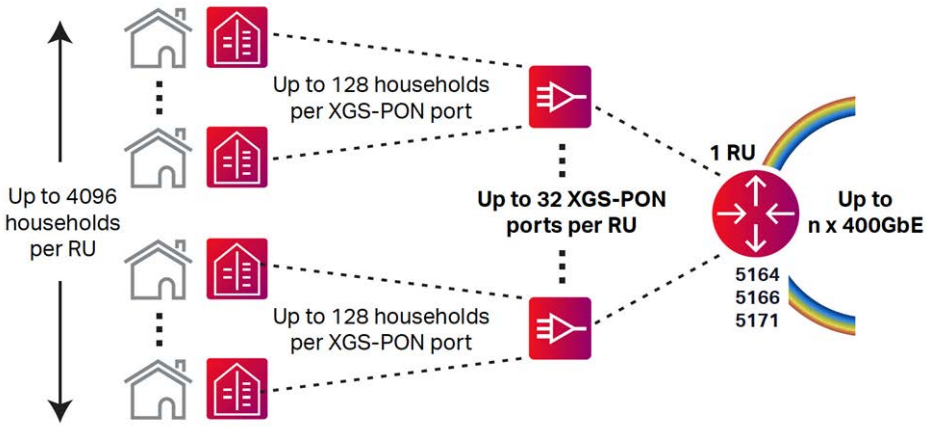



*Figure 2: Ciena's Residential Broadband Solution*

## Delivering a converged network for smart grid and broadband services

A change of this magnitude in the network—combined with the introduction of completely new service types at the same time—may be viewed as high risk. There are also cultural factors to consider when merging the traditionally separate OT and IT network and teams. This can be mitigated with a plan that divides the transition into three steps.

The first step is to build a middle-mile network to support smart grid traffic. This provides confidence that the solution performance meets the needs of mission-critical teleprotection and other high-volume traffic, such as surveillance cameras and smart meters.

*continued from page 23*

The second step is to offer residential broadband services in rural communities provided through the same network for smart grid. Ciena offers a highly scalable approach that allows utilities to easily go from tens to hundreds of XGS Passive Optical Network (PON) ports without losing sunk platform investments, replacing existing network equipment, or needing significant upfront costs. Ciena's Universal Aggregation (UA) and access capabilities support multiple service options in addition to XGS-PON.

The final step is to offer wholesale and business connectivity services. For example, in regions with 5G rollout in progress, mobile carriers will be looking for a significant amount of additional capacity. In both the business and public sectors, there are opportunities for capacity to support business applications, telemedicine, or remote learning.

With this solution modularity, utilities can offer enterprise business services over IP or dedicated Ethernet and mobile wholesale services with xHaul transport capabilities. Moreover, they can have a highly-optimized footprint that reduces energy and space requirements to sustainably expand addressable market and revenue opportunities. Hardened and weatherproof platforms provide utilities with maximum flexibility and the ability to move their Optical Line Terminals (OLTs) closer to end-users for improved performance. This solution leverages the power of Ciena's portfolio, including Routing and Switching platforms with XGS-PON pluggable technology, market-leading optical networking technology, Ciena's Manage, Control and Plan (MCP) domain controller, Blue Planet® Intelligent Automation Software, and Ciena Services.

## Broadband beyond the network elements

Utilities are looking to deliver the best Quality of Experience (QoE) to their customers while increasing operational efficiencies. As networks have grown, broadband network planning, infrastructure commissioning, service fulfillment, and service assurance can be complex. Ciena's PON Operations, Administration, and Maintenance (OAM) software simplifies network and service management. PON OAM can be cost-effectively hosted on an external x86 server or internally on Ciena's Universal Aggregation platforms as part of WebGUI.

Ciena's Residential Broadband Solution also leverages Ciena's MCP domain controller. This allows utilities to scale the network, simplify operations, reduce cost, and deliver the agility and resiliency their customers expect. It provides utilities the ability to manage and orchestrate their multi-layer network from end to end—including middle mile, last mile, and Customer Premises Equipment (CPE)—when delivering broadband, enterprise, or mobile wholesale services using a common and integrated platform.

## Full support to new and existing utilities

As many utilities may not necessarily be set up to execute complex IT deployments, Ciena Services' extensive experience, processes, and economies of scale can help assure a successful rollout. Depending on needs, Ciena Services is ready to assist—from initial planning and design, systems integration, and implementation to 'Day 2' services to optimize, support, and manage this powerful solution. Ciena Services also offers an extensive library of learning courses and labs to grow IT teams' residential broadband knowledge. Ciena's services are designed to be flexible—they are available individually or as a packaged solution—and consist of Consulting, Implementation, Systems Integration, Maintenance, Managed Services, Optimization, and Learning.

Ciena's solution also includes the Ciena Partner Network's Marketing as a Service program (MaaS)—an award-winning marketing service that takes network operators to market faster with collaborative engagement, execution, and dedicated marketing experts to accelerate time to revenue. Ciena not only supports the development of go-to-market strategies, but also executes to win business together.

Utilities are moving away from legacy chassis-based approaches because they simply do not offer the capacity, efficiency, or adaptability required to succeed in a highly competitive market while supporting new and emerging application requirements. Ciena leverages innovative broadband architecture and proven expertise in deploying ultra-high-capacity networks to thrive in the growing residential broadband market.

## Sustainability cannot be an afterthought

Investing in infrastructure to close the digital divide without considering all relevant environmental and economic sustainability aspects can negatively impact any service provider's long-term financial viability.

At Ciena, we continue to invest in the sustainability of all critical network elements by converging the access infrastructure with best-in-class routers, WaveLogic™ coherent optics, and innovative uOLTs and corresponding ONUs.

Sustainability models show we have already helped our customers avoid more than 550,000 metric tons of $CO_2e$ over an eight-year period (2014–2021) with our Routing and Switching Platforms—helping our customers' production networks achieve 23 percent savings in power consumption, equaling 96,000,000 kWh saved which resulted in $12 million per year OPEX savings.

Through our WaveLogic coherent optic investments, we introduced the industry's first 400 Gb/s transceiver in 2017 and are delivering the pluggable version five years later at one fifth the power, one tenth the space, and with improved industry-leading systems performance.

Combining Ciena's routing, optical, and PON innovations together offers significant improvements in footprint and power savings to enable more efficient and sustainable networks for our customers—and the planet at large. For example, evolving from a traditional pure PON chassis-based, multi-boxed solution to Ciena's converged access with XGS-PON and routing in a single platform results in a 67 percent reduction in footprint and 63 percent reduction in power consumption. This is just one example and, when applied to 100,000 homes passed at 50 percent market share (12 sites) using a 64 OLT split, can avoid 84,400 kWh annually, resulting in 59.8 metric tons of $CO_2e$ avoided. A higher market share rate or homes passed would yield much larger sustainability results.

To quantify the value of Ciena's sustainable approach to broadband, we have partnered with ACG to develop an on-line business case tool that can quantify the TCO advantages of Ciena's broadband architecture vs legacy chassis-based and closed pizza box approaches. Our subject matter experts will work with the customer to analyze their planned rollouts and develop both a 5-year TCO and ROI analysis tailored to the customer's network needs.

We welcome utilities that are in their planning stages for broadband to reach out to us to take advantage of these on-line business case tools to aid them in their broadband journey.

# THE POWER OF FIBER

## How Investments in Fiber Promote Economic Growth for Local Communities

**BY: CORNING OPTICAL COMMUNICATIONS**

### A Historical Investment in Fiber

The power of fiber to help local communities grow is immense. But let's start with why now is the right time to get into fiber in the first place.

There has never been a better opportunity for utilities, telecommunications providers, and governmental institutions to make an investment in new fiber networks. Why? We live in an era of unprecedented investment in expanding and enhancing broadband networks across the United States. Here's a snapshot of the recent funding available through federal and state governments:

- The Infrastructure Investment and Jobs Act of 2021 (IIJA, also known as the Bipartisan Infrastructure Law) set apart more than $65 billion for broadband infrastructure deployment. Three of its programs take specific aim at the creation and enhancement of broadband networks:
  - The Broadband Equity, Access, and Deployment (BEAD) Program offers a minimum of $100 million to each state and $25 million to each U.S. territory for the creation of broadband networks. The BEAD Program is expected to prioritize fiber projects in underserved areas.
  - The Enabling Middle Mile Broadband Infrastructure Program is a nearly $1 billion fund allowing governments, nonprofits, and industries like telecommunications companies and utility cooperatives to receive grant funding to build and expand middle mile networks.
  - The Tribal Broadband Connectivity Program sets aside almost $1 billion for Tribal governments to deploy broadband and enhance the digital lives of Tribal members through broadband affordability, telehealth, distance learning, and other programs.
- The American Rescue Plan Act of 2021 allocated $350 billion to state, local, and Tribal governments. Billions of American Rescue Plan dollars have already been awarded toward broadband infrastructure projects. In January 2022, the Treasury Department expanded the funding rules to allow for more broadband projects.

- The list goes on with older programs, including:
  - The Consolidated Appropriations Act (passed in 2020): $5 billion for broadband-related issues
  - The Rural Digital Opportunity Fund (launched in 2020): $20 billion for broadband in rural areas
  - The USDA's Rural Development Broadband ReConnect Program (launched in 2018): More than $1.1 billion for broadband deployment

The funding is on the table, waiting to be claimed. There may never be a better time to begin, expand, or improve your fiber network.

### What Fiber Can Do for Communities

Why fiber, and what will it do for your community? Fiber is uniquely positioned to power economic development and here's why:

- The speed and low latency offered by fiber networks is unmatched. Fiber offers a completely transparent connection with symmetrical speeds possible far beyond what most homes and businesses need.

- Converged access networks mean that a single fiber network can power residential, business, enterprise, and wholesale applications—signals can be aggregated into a single strand of fiber and disaggregated to provide fiber to the home, the business, the wireless tower, and to whatever the future demands.

- Fiber networks offer possibilities for redundancy and uptime monitoring that make fiber not only the fastest but also the most reliable form of broadband.

Communities in which fiber networks are built almost instantly have access to innumerable opportunities that a fiber connection provides. For example:

- **Homes with a fiber connection** empower their residents to telecommute with the reassurance of a strong, dependable connection and offer opportunities for smart home services and online learning.

- **Hospitals and doctor's offices** can offer reliable telehealth, including the ability to consult with out-of-area health professionals who may have specialties or expertise previously unavailable to the community.

- **Farms powered by fiber** can use video technology to monitor fields and sensors that help manage smart watering systems.

- **Local schools** can offer students access to tools that weaker, slower connections can't provide. Fiber becomes an investment in the economic success and growth of a community as educational opportunities improve.

*continued from page 27*

These examples merely scratch the surface. But what can research and existing fiber deployments tell us about the true power of fiber? Read on.

## Real-World Examples and Statistics

When it comes to the power of fiber to promote a community's economy, the data is clear and offers proof behind the theory. Here are just a few remarkable real-world examples:

- **Fiber increases local business revenue**. Earlier this year, an RVA Market Research & Consulting study concluded that "over $78 million per year of additional primary revenue from home-based businesses could be gained from an FTTH community of 100,000 households." This study also showed that, for home-based businesses on a fiber connection, income from outside the community was 73% higher than it was for home-based businesses on a different kind of connection.

- **Fiber increases employment rates**. A University of Missouri study on the impact of wired broadband during the COVID-19 pandemic showed links between wired broadband availability and adoption: they correlated a 1% increase in availability to a .37% increase in rural employment rates, and a 1% increase in adoption to a .87% increase in rural employment rates. Consulting firm Deloitte created economic models that reinforce this link between broadband availability and employment. Their 2021 report concluded that, had there been a 10% increase in broadband penetration in 2016, 806,000 additional jobs would have been created by 2019 (an average annual increase of 269,000 jobs).

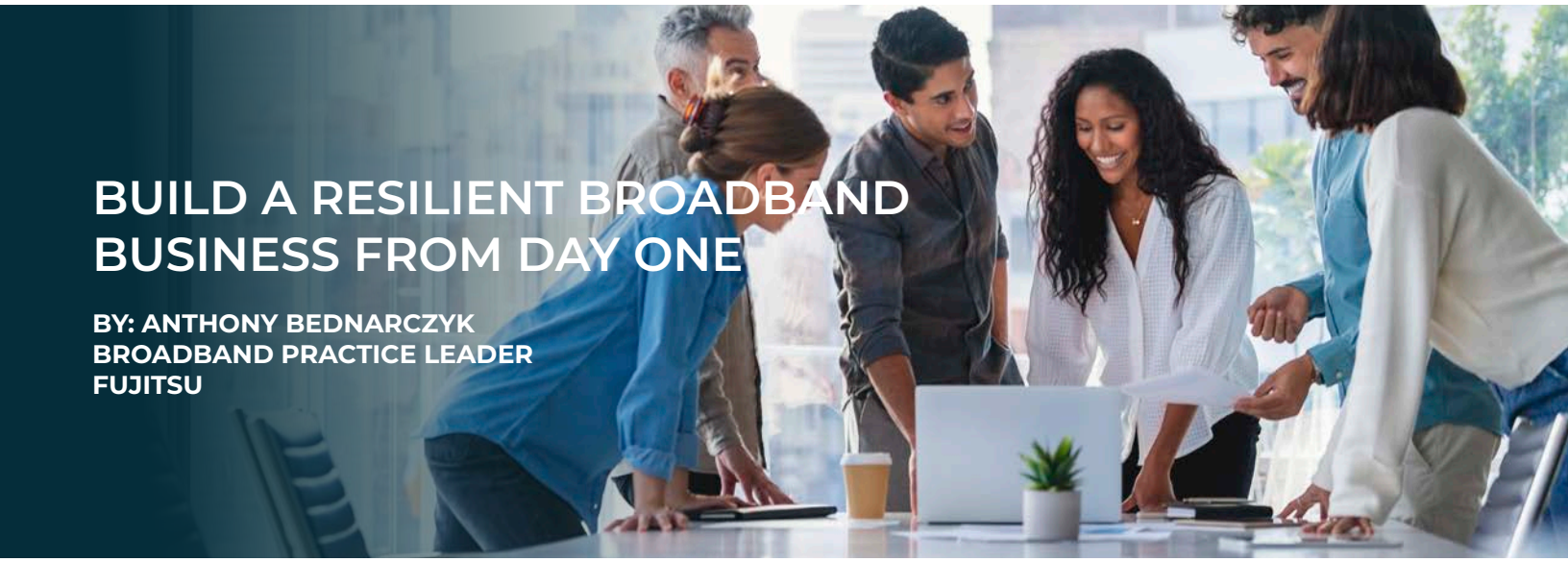
- **Fiber increases local residents' incomes**. After the small city of Westfield, Massachusetts deployed their fiber network, a Futuriom study concluded that the city of just over 40,000 residents saw over $88 million annually in job-related benefits.

- **Fiber attracts companies to communities**. Todd Way of Douglas Fast Net—which deployed fiber in rural Oregon—says of the power of fiber, "Fiber broadband… [is] playing a key role in helping keep some of our largest employers in the area and attract new businesses and industries to our market." Additionally, pole-top cameras were installed as Douglas Fast Net constructed the fiber network, which has allowed wildfire teams to track and locate fires and work to fight them.

As more Americans have access to fiber networks, statistics and stories like these will become the norm.

## Conclusion

Fiber broadband is a driver of economic growth for communities small and large, urban and rural. The potential growth afforded by fiber is good news for every community in the country, and there has never been a better time to lead the way toward—and find the funding for—fiber broadband deployment.



# BUILD A RESILIENT BROADBAND BUSINESS FROM DAY ONE

**BY: ANTHONY BEDNARCZYK**
**BROADBAND PRACTICE LEADER**
**FUJITSU**

Starting a broadband business from scratch can be a daunting task, but with the right approach and guidance, it is possible to build a successful enterprise to serve your community and stakeholders. The broadband industry has seen steady growth in recent years, and as demand for faster internet speeds and greater connectivity continues to rise, the market presents an exciting opportunity for communities and infrastructure investors.

As today's utilities face rising costs, grid resiliency challenges, unpredictable extreme weather conditions and potential cyberattacks, many electric cooperatives are interested in the opportunity to transform their business by building a new broadband network. Beyond being a smart investment that enables a more resilient electric grid, fiber infrastructure allows rural cooperatives to better serve their communities by offering affordable, high-speed internet services to bridge the broadband gap.

To build a broadband business from day one, there are several important considerations to keep in mind. These include securing funding, establishing sound business management and governance practices, implementing effective network operations strategies, and focusing on continued improvement.

## Lay the Groundwork

One of the first steps in building a broadband business is to secure funding. Federal and state governments have tried to make significant investments in expanding broadband access in rural areas and other underserved communities, and communities and other organizations can take advantage of these opportunities to secure funding for their projects.

There are several grant programs for broadband, including the Infrastructure Investment and Jobs Act (IIJA), Broadband Equity, Access and Deployment (BEAD) fund, USDA's ReConnect Program, and the American Rescue Plan Act (ARPA). These grant programs provide funding for infrastructure development, network expansion and other initiatives that support broadband deployment. These funding sources do come with quite a bit of competition, paperwork and requirements to be met, however, so this might require the help of an expert to ensure a strong and complete application.

When applying for grant funding, it is essential to have a clear and compelling business plan that outlines the scope of the project, the target market and expected outcomes such as greater access and affordability. Successful grant applications also demonstrate a strong commitment to sustainability and long-term viability, which is critical for securing ongoing funding and support.

Likewise, private capital is a growing part of the broadband story as well, and many investors are looking to find ways to be a part of solving the digital divide while gaining a stable and long-term investment.

Managing expectations also will be important as the planning process moves forward. Implementing a new business model may require more leadership oversight to align to internal targets, such as reaching a break-even point quickly. Furthermore, regulatory agencies have expectations about reporting deadlines, and community stakeholders will anticipate regular updates as they become invested in the project.

A good example of how to manage expectations is the case of a municipal broadband utility in Fairlawn, Ohio, that continually informs stakeholders about future expansion plans and funding needs. This constant communication effectively provides transparency for the community as well as marketing the utility's broadband service to potential customers.

## Balance Business Priorities

To build a successful broadband business, it's important to establish sound business management and governance practices from the outset. This includes developing a clear organizational structure, creating effective policies and procedures, and implementing strong financial management practices.

It's essential to have a strong leadership team in place, with individuals who have the experience and expertise needed to guide the company through the challenges and opportunities of the broadband industry. This team should include professionals with a deep understanding of the technology, regulatory environment and market dynamics of the broadband industry.

To deliver reliable, high-quality broadband service, effective network operations strategies are critical. This includes investing in state-of-the-art equipment, software and infrastructure, as well as developing strong relationships with vendors, suppliers and other key stakeholders.

Additionally, it's also vital to have a robust network operations center (NOC) in place, staffed by trained professionals who can monitor network performance, troubleshoot issues and ensure that service levels meet or exceed customer expectations. There are many ways to achieve these end goals. For some cooperatives, the best answer may be to seek help from vendors with established expertise, NOC availability, and access to equipment and materials to keep the project on track.

In many cases, operating a broadband network may not be within the scope of responsibilities for existing personnel. When hiring staff, it's essential to consider how their training will be handled, and if they will work on all aspects of the business or just focus on a single area. By cross-training employees, a cooperative can reduce operating costs, optimize productivity and build skill redundancies.

On the other hand, when the expertise isn't available in-house, it often may be difficult to find the right personnel even throughout the region. In these instances, or if a cooperative chooses to simply focus on their core business, broadband challenges may be best solved by augmenting resources with the help of an expert network systems integrator, like Fujitsu, bringing years of networking experience and dedicated resources to the task at hand.

Regardless of whether management is outsourced or handled in-house, how can the cooperative balance the business needs and objectives between being a broadband service provider and providing electric service?

Organizational planning is key to clarify how much time is being spent on what, who will handle different functions, and ensure reliability on both sides, in order to make sure customers are not negatively impacted by a sudden event.

Don't overlook the possibility that an actual separation between the two businesses may be necessary to meet expectations of staff and stakeholders. In fact, when Craig-Botetourt Rural Electric Cooperative (CBEC) in southwestern Virginia decided to offer broadband services, the State Corporation Commission of Virginia required the cooperative to establish a subsidiary to handle administration of their high-speed broadband business. In addition to enabling the management team and board of directors to abide by regulatory requirements, this separation also helped to provide greater clarity on what resources were allocated to each function.

## Build for Tomorrow

Finally, to build a successful broadband business, it is important to focus on continuous improvement. This includes investing in your network to stay on the cutting edge of technology, seeking out new opportunities for growth and expansion, and continually refining business processes and practices to optimize performance.

Even after the milestone of turning up broadband service has been achieved, it's vital to keep planning for the future. What is the best way to expand and improve service, and how can operations be simplified? The best practice is to implement a formal process of continuous improvement, which might include staff training, regular input from stakeholders, a review of lessons learned, or talking to industry consultants and vendors for new ideas.

Looking forward to the future, be sure to keep new customers' needs in mind to align current service offerings and future network upgrades. For example, smart agriculture applications are quickly being developed, which might involve different technologies versus a typical fiber-to-the-home (FTTH) broadband network. Other potential use cases to consider include communications for maintenance drones and the needs of local government agencies, schools or libraries.

## Plan to Succeed

One way to achieve these objectives and build a successful broadband business from day one is to work with a turnkey partner. A turnkey partner can provide expertise in securing federal grant funding, establishing sound business management and governance practices, implementing effective network operations strategies, and focusing on continued improvement.

Working with the right partner can also help cooperatives navigate the complex regulatory environment of the broadband industry, stay on top of emerging trends and technologies, and identify new opportunities for growth and expansion.

Building a successful broadband business from day one requires careful planning, sound business management and governance practices, effective network operations strategies and a commitment to continuous improvement. Working with a turnkey partner can help communities and investors achieve these objectives and build a thriving enterprise in the dynamic and exciting broadband industry.

With a strategic investment in fiber broadband, electric cooperatives can do more than just survive — they can grow and flourish for the future. More importantly, the communities they serve also will thrive, thanks to the benefits that broadband access delivers: quality of life, enhanced business prospects, modernized services and long-term growth. While the path to broadband may seem a bit rocky at first, starting strong on solid footing with the right partner by your side means you can be confident of success for the long haul.

# THE FUTURE OF PON

**BY: NOKIA**

Fiber is the driving force of the broadband connectivity today. It is the biggest and fastest growing fixed access technology with the largest eco-system of players that includes fixed and converged operators, governments, cities, utilities, enterprises, and infrastructure investors. Fiber broadband investment is attractive because it enables a premium customer experience, competitive advantage, the lowest operational costs (OPEX), and the lowest power consumption of any broadband technology, with the additional opportunity of service convergence (residential, enterprise and 5G transport).

One of the greatest attributes of fiber is unlimited bandwidth potential. As technology evolves, the same fiber networks will be able to increase capacity using the same fiber infrastructure, without the need to make updates in the most valuable part of the network: the fiber outside plant.

The increase of capacity is possible by adding new wavelengths (or colors of light), each wavelength carrying data traffic and even working on different transmission rates. New fiber technologies unlock the potential of fiber to be a single infrastructure that underpins the entire telecom eco-system and connect everything and everyone: consumers, businesses and even 5G cell sites.

Today, fiber networks are based on Gigabit PON (GPON). The next step is XGS-PON which reuses the same outside fiber plant (fiber cables, splitters, and access nodes) to increase bitrates to 10 Gb/s. The industry is already working on further evolutions beyond 10 Gb/s. The next generation of PON technologies are essential to meet ever-growing bandwidth demand and ensure that the fiber networks built out today can be used for decades to come.

This article examines the future PON fiber technologies beyond 10 Gb/s.

## The history of PON and the new paradigm

Previous generations of PON technology have derived their origins from long-haul optical technologies. After these technologies were adopted by the metro market, they drove component volumes and maturation further and eventually reached a price point that became viable in a massive-scale fixed access deployment. These technologies have had to be adapted for larger power budgets and the burst mode operation used in PON. Nevertheless, the trickle-down process has worked well, spawning EPON, GPON and 10G PON technologies.

The future generations of PON will use a slightly different, but highly efficient path. They will be based on the world of data centers and, specifically, 100G Ethernet technologies with 25 Gb/s channels that are used for intra-data center connectivity.

The increased demand for data center capacity, much of it on single-mode fiber, has begun to drive large volumes and reduced costs on 25G components. This is the mature ecosystem that the next generation of PON leverages, and 25 Gb/s will be the baseline for the next steps: 25G, 50G and 100G PON.

Is it possible to just plug these data center components into OLT and ONU transceivers? Of course not. PON applications will require new wavelengths, a higher launch power from transmitters, and greater sensitivity from receivers. However, this is no different from the work that has been done for previous PON generations based on components from long-haul and metro transceivers.

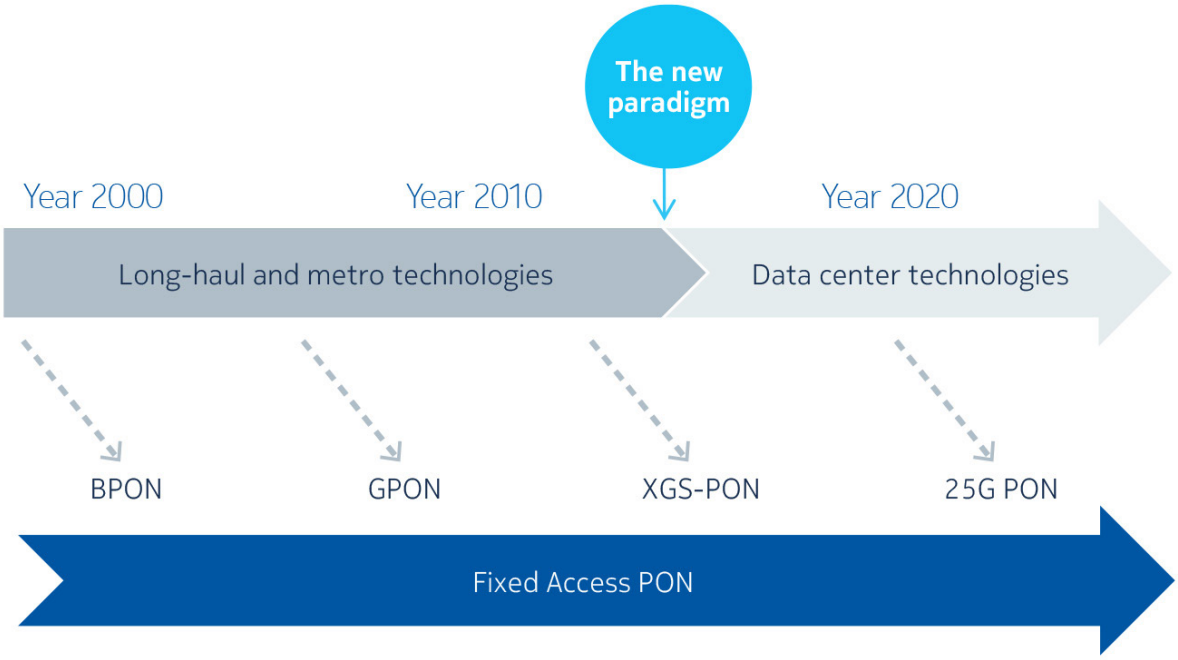



*Figure 1: PON evolution depends on the pre-existence of mature optical and electronic technologies. 25G PON leverages mature Data Center optical technologies.*

## 25G PON: the best next step

For an access technology to be successful, a few significant requirements need to be fulfilled. The first is cost efficiency, which includes CAPEX and cost of introduction, etc. In massive access networks deployments, where millions need to be connected, cost-efficiency is key. There are examples of technologies that have a very attractive value proposition but, because of complexity and a very high cost, they did not become widely adopted. Next, there must be well-defined, viable use cases in the near- and mid-term for the technology. 25G PON fulfils these conditions.

**Cost efficiency.** 25G will be the most cost-effective evolutionary step for the next decade. It leverages mature and massively deployed data center technologies. It is a simple technology which does not require advanced digital signal processing (DSP), amplifiers or tunable lasers. 25G PON is likely to be the last step in the evolution that will be a straight evolution from 10G PON: steps beyond 25G will be a technology leap and require advanced DSP and optical amplifiers or even coherent, all of which will take years to mature.

*continued from page 33*

**Use cases.** The massive capacity of 25G PON will enable unified services—connecting everyone and everything over a single high-performance network. Operators are already seeing the demand for speeds beyond 10 Gb/s to:

- Connect enterprises with true 10G (current marketplace) and >10G speeds for bandwidth-demanding, latency-sensitive applications, and enable greater ARPU vs. residential services.
- Provide mobile transport (i.e., X-haul) for the high volume of traffic from densely deployed 5G antennas.
- Wholesale providers need big pipes to meet the demand of all their tenants and applications. 25G PON is ideally suited to network slicing, which can be used to maximize network utilization and differentiate quality of service (QoS) for each tenant or service.
- Enable next-generation services and capabilities like remote surgery, massive scale Virtual Reality, real-time digital twins, etc. Although the residential market is not yet a strong driver for 25G PON, some operators will consider it for disruptive true 10G services or for cost optimization with high split ratios in greenfield environments.

**Huge capacity.** 25G PON is 10x faster than GPON and 2.5x faster than XGS-PON. The Ethernet market has found that a step increase in speed by a factor of 2-2.5x delivers the best commercial results. The 25G step has been adopted by IEEE (25G EPON), data centers, WDM, G.metro and 25GS-PON MSA. It is driven by concrete demand for enterprise services and 5G transport and will be able to meet residential demands when the time comes. To illustrate: today, 1 Gigabit is a product for premium connectivity in many markets, and 25G (when overheads are accounted for) is 20x faster. That should be enough bandwidth for at least the next decade.

**Simple introduction.** Co-existence is a major requirement for ensuring graceful migration and avoiding complicated (and costly) operations. Network upgrades don't happen overnight, they are done gradually, so old and new technologies will need to co-exist for many years. By the time upgrades to >10G are needed, most networks will have both GPON and XGS-PON in the field.

One of the great attributes of 25G PON is that it can seamlessly co-exist with both GPON and XGS-PON, so there can be three generations of PON on the same fiber infrastructure, which enables operators to use the right technology and speeds for each service. There are no forced migrations, no restrictions, and no overlay deployments.

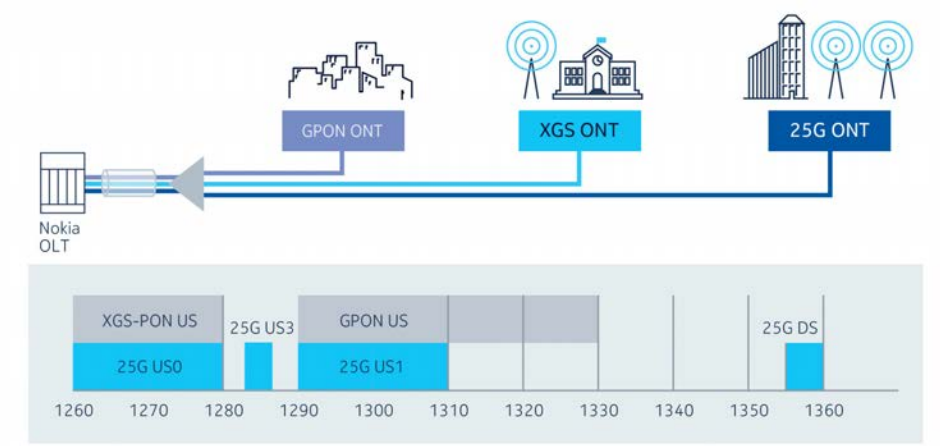



*Figure 2: 25G PON wavelength plan ensures triple co-existence (GPON, XGS-PON and 25G PON)*

**Availability.** Operators are already seeing the need for capacity beyond 10 Gb/s and 25G PON is available today. Operators will be able to react quickly when needed and protect their business. Waiting for a new technology—and losing opportunities in the meantime—is not an option.

This is why 25G PON is so important. It is available today, has huge capacity and is very easy to introduce. 25G PON was already introduced in a live network.

### 25G PON implementation

The guiding principle of 25G PON is to deliver 2.5x more bandwidth at <2.5 higher cost. The strategy to lower the incremental cost is composed of the following elements:

- **O-band wavelengths.** Dispersion increases with higher bit rates. 25G PON downstream and upstream wavelengths need to be in the O-band to avoid large penalties or the need for dispersion compensation.

- **Transmission.** While leveraging data center technologies, 25G PON does not require all the functionalities needed in data centers. Instead of higher-level, costly modulation schemes like PAM4, it can use simple non-return-to-zero (NRZ) transmission.

- **Optical amplification.** 25 Gb/s has about a 5 dB power penalty compared to 10 Gb/s. To achieve a 29 dB (PR30 EPON, N1 class ITU-T PON) loss budget, and to avoid the cost of optical amplification, those 5 dBs need to come from a combination of higher launch power, improved receiver sensitivity and stronger FEC. This will be possible, but with little margin to spare.

- **Dual-rate transmission.** 25G PON supports both symmetrical (25/25) and asymmetrical (25/10) bitrates. This enables the use of lower cost 25G/10G ONTs where symmetry is not needed.

The 25G-PON standard specifies 1358 nm wavelength in downstream and three options for upstream:

- Option 1: 1300 nm (subset of GPON) for co-existence with XGS-PON.
- Option 2: 1270 nm (same as XGS-PON) for co-existence with GPON.
- Option 3: 1286 nm to support triple co-existence of 25G PON, XGS-PON and GPON.

This choice of wavelength plan ensures a smooth evolution path in any network.

### The path to 50G PON

The standardization work on 50G PON G.hsp (Higher Speed PON) is already under way and Nokia is one of the main contributors to the ITU-T standardization work. The evolution to 50G PON is a long-term evolution, and it is more of a quantum leap than an evolution. Running at such high speeds has several engineering challenges. Tweaks to address these challenges increase the complexity and cost, and time to mature.

50G PON will be able to use some 25G components but not everything. It will need new, more costly 50 Gb/s transmitters and amplifiers (EML+SOA). This is because when a 25 Gb/s transmitter tries to transmit at 50 Gb/s, the signal is distorted. To compensate, 25G transmitters will need to be used in combination with optical amplifiers. The alternative is to use 50G transmitters. In both cases, the cost is higher.

*continued from page 35*

50G PON can leverage 25G optical components in receivers, but it will need advanced DSP to be able to achieve 50 Gb/s bitrates with 25 Gb/s optics. This adds significant cost. In fact, that will be the case with all technologies beyond 25G PON. To bring the cost down, DSP must be integrated in SoC (system on chip) and reach high volumes, which will take time. It is expected that 50G will not take off in the next 7-8 years. This also means there will not be mass volumes before 2030 to drive down the cost. None of this is an issue for 25G PON.

50G PON will require optical amplifiers for all loss budgets. For higher speeds, there is a higher power penalty at the receiver so, to compensate, 50G PON needs to launch at a higher power at the transmitter.

Although Nokia Bell Labs has had a 50G PON demo for some time, and early industry prototypes are being available, it does not mean that 50G will be deployable soon. There is a need for further research work to optimize the technology. For example, the practicality of high loss budgets (>29 dB) is still to be determined. The symmetrical bandwidth is still under evaluation (note that the 50G standardization deferred the specification for 50G in upstream because of its complexity and has standardized 12.5Gb/s and 25Gb/s in upstream).

Another challenge of 50G PON is the co-existence with other technologies. The current specification enables co-existence with GPON or XGS-PON but not both at the same time. Consequently, operators who want to introduce 50G PON in their networks must either decommission their GPON network first and move all customers to XGS-PON, or skip the XGS-PON step and upgrade GPON to 50G PON directly. This clearly complicates the evolution path, which is not the case with 25G PON, as it can co-exist with GPON, XGS-PON and even 50G PON simultaneously on the same PON.

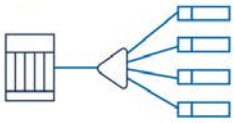
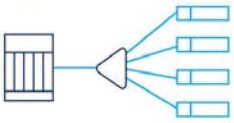
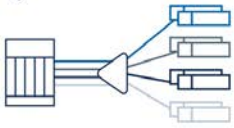
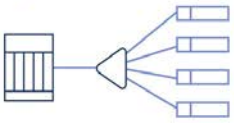
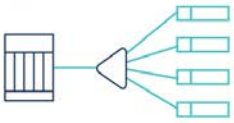
| GPON | XGS-PON | TWDM-PON | 25G PON | 50G PON |
|---|---|---|---|---|
| Gigabit PON | 10G symmetrical PON | Time wavelength division multiplexing | 25G symmetrical PON | 50G asymmetrical PON |
| 2.5 Gb/s<br>1.2 Gb/s | 10 Gb/s<br>2.5 or 10 Gb/s | 4 x 10 Gb/s<br>4 x 10 Gb/s | 25 Gb/s<br>10 or 25 Gb/s | 50 Gb/s<br>12 or 25 Gb/s |
|  |  |  |  |  |
| One fiber feeder is split to connect multiple users. Total bandwidth is shared between all users. | Same principles as GPON, but faster. Enables dual rates: symmetrical or asymmetrical. Co-existence: GPON, 25G PON and TWDM-PON. | Uses 4 wavelength pairs (4 in upstream, 4 in downstream). Multiple users share a wavelength. Co-existence: GPON, XGS-PON and 25G PON | Same as GPON and XGS-PON but faster. Enables dual rates: symmetrical or asymmetrical. Co-existence: GPON, XGS-PON,TWDM and 50G PON. | Uses single wavelength pair. Technology leap. Asymmetrical bitrates only Co-existence: GPON or XGS-PON, 25G PON. |
| Deployments: Most widely deployed PON worldwide | Deployments: Accelerating worldwide | Deployments: Limited | Deployments: Emerging | Deployments: ~2030 |

***Figure 3: Overview of TDM PON technologies***

## The futuristic 100G PON and beyond

Nokia Bell Labs recently showed the industry's first 100G PON demo. Bell Labs leveraged the same base technology that is needed for 50G PON using advanced DSP techniques that are not yet commercially available. Once there is a baseline ecosystem for 50G PON, the step to 100G PON will follow quickly.

The Bell Labs demo also demonstrated Flexible Data Rates, which is an industry-first in PON networks. Flexible rate transmission groups ONUs that exhibit similar physical network characteristics (e.g., located at around the same distance from the OLT, with similar loss or dispersion). ONU groups benefit from dedicated, optimized performance e.g., more efficient data transmission, lower latency, and lower power consumption. Note that Flexible Data Rates is not a feature that is directly linked to 100G PON; it could be implemented for any PON technology.

The higher speed of 100G PON brings a power penalty at the receiver. In 50G PON, this problem can be solved by a higher launch power at the transmitter. However, for 100G PON this is not a practical approach, and more advanced solution for the receiver must be found.

To fulfill a 29 dB and 32 dB loss budget, 100G TDM-PON will probably require a coherent receiver. For symmetrical 100G, a coherent burst mode receiver will be required, and this is an active area of research. There are at least three possible scenarios that could lead to a practical 100G coherent PON in the second half of the next decade:

- Leverage traditional long-haul and metro 100G coherent, if the costs erode to PON price points (not likely)
- Leverage data centers coherent (likely in the mid-2020s), with performance-cost trade off, which would be possible because shorter distances are used.
- Optimize coherent architecture specifically for PON.

Regardless, the PON industry has a few years before needing to make technology decisions about 100G PON.

Once coherent technology proves-in for TDM PON, the sky is the limit. 400G coherent is already deployed today in core, metro and lately DCI networks, and commercial systems supporting more than 400G are emerging.

## Conclusion

It is important to keep pushing the boundaries of PON technology and make sure the investments in fiber networks made today will be usable for many years to come to meet the inevitable growth in demand for faster, more responsive, and immersive internet services.

The industry is already embracing 25G PON and the research work on 50G and 100G PON is ongoing. Nokia is leading the industry, with the first 25G PON commercial solution that has been deployed in a live network. We are one of the main contributors to the ITU-T 50G PON standard. In early 2021, we demonstrated the industry's first 100G PON prototype.

However, 50G PON and 100G PON are still far from being deployable. They require more research, development of a new generation of lasers, optical amplifiers and DSPs, and further optimization to reach maturity and an acceptable cost point. These advances in technology will ensure the evolution of fiber networks and demonstrate the superiority of fiber to serve as a unified infrastructure to connect everything, everywhere.

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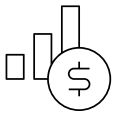

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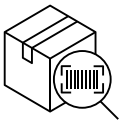

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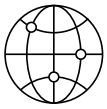

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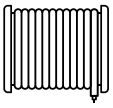
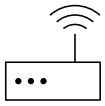


Distributing **8 million+**
miles of fiber annually



Refurbished over **6.5 million**
CPE units last year, helping our customers go green and reduce capex

Supplying **70+**
carriers in Europe, Middle East, and US

The SCOOP

The information provided in this catalog is intended for informational purposes only and is subject to change without notice. Netceed may also make improvements and/or changes in the products described in this catalog at any time without notice.

Netceed | 225 Raritan Center Parkway | Edison, NJ 08837
1-800-423-2594 | www.netceed.com