NOKIA

Fiber for Everything

A new era where fiber PON infrastructure connects everything and everybody

White paper

Fiber is the fastest, greenest, and most widely deployed broadband technology in the world today. And it keeps getting better.

Recent advances in fiber performance mean fiber broadband can do more than just fiber-to-the-home. Fiber is everywhere, so it can be used to connect everything: homes, businesses, Industry 4.0, smart cities, and 5G cells. All on the same fiber infrastructure.

Fiber for Everything means operators can deliver all their services on a single, high-performance fiber network, generating more revenues, introducing 5G small cells more quickly, reducing power consumption, and lowering the total cost of ownership.

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Contents

Fiber is the future

Fiber is the biggest and the fastest growing fixed access technology in the world today, accounting for 75% of all fixed broadband connections in 2022.

Fiber's growth has been driven by a universal thirst for high-speed connectivity and accelerated by the changes in digital behavior created by the COVID-19 pandemic. As the most future proof and greenest way of bringing high-speed broadband to the masses, there is a strong desire from broadband operators and governments to switch out legacy infrastructure for fiber.

Fiber's success is, in no small part, due to the ease of evolution. Each new generation of passive optical network (PON) technology (e.g., GPON, XGS-PON, 25G PON) can be introduced into a network without needing to touch the outside plant. Once fiber broadband infrastructure is deployed, it can be used for 50+ years. This longevity means fiber is here to stay.

In addition, recent advances in PON technology have led to a shift in thinking about the role of the fiber access network. From being mostly reserved for residential broadband services, it is now increasingly viewed as an infrastructure capable of connecting everything and everyone. Industry 4.0, 5G mobile transport, smart cities, wholesale, business and residential broadband services are all opportunities for a single high-capacity, high-performance, fiber access infrastructure. Thus, we are seeing a shift from fiber-to-the-home to Fiber for Everything.

Fiber for Everything supports more services and generates more revenue streams, which means faster monetization and a better ROI. The attractiveness of the Fiber for Everything business case is driving increased investment, attracting new investors and accelerating fiber broadband deployments around the world.

Technology advances

The concept of a single, high-revenue generating network capable of delivering all services is hugely compelling and has been discussed for many years. It is now a viable opportunity for two reasons. The first is availability: fiber is (almost) everywhere, it passes every street, every corner, every building, so it can be leveraged for more than residential services. There is no need to trench streets to add additional fiber for businesses or anyhaul, which results in lower overall costs, and a fast time to market to connect new end points.

The second driving factor is the ever-improving performance of PON.

Multi-Gigabit capacity

Over the last 15 years, the bitrates achieved on fiber have increased by a factor of 100. GPON, XGS-PON and now 25G PON deliver multiple Gigabits of capacity, and there is no sign of stopping. With future 50G and 100G PON technologies already successfully demonstrated and standardization in the works, PON continues to be the future-proof technology we need.

PON now has the huge capacity capable of carrying multiple services from multiple networks all on a single fiber infrastructure. In addition, fiber is flexible enough to allow these services to use different PON technologies with different bitrates, each carried on a dedicated wavelength, all co-existing on the same fiber. Each service can use the technology that is the best fit from a performance or business case perspective; for example, XGS-PON for consumers and small businesses, 25G PON for enterprises and mobile transport.

Zero-touch operations

The second enabler of unified fiber are advances in software-defined access networking (SDAN) and the network programmability in the cloud. SDAN takes a set of network functions and data out of the network elements and hosts them in the cloud. From there, network operators can run algorithms and analytics, resulting in a programmable and automated network which is easy to integrate and operate even in a multi-service, multi-technology, multi-vendor environment.

Network slicing

SDAN also brings network slicing: the ability to slice a physical network into multiple discrete virtual networks. Each virtual slice can be optimized to support a specific service; for example one slice can be used for residential broadband, another for business services, a third for mobile transport or smart city services or wholesale, etc. To meet the demand and SLA of each use case, the network slices can have different network parameters (speed, latency) and can be managed independently. This provides greater flexibility for all organizations who want to share the common infrastructure and still manage it the way that best fits their needs, independently of the needs of others.

Mission critical reliability

Until recently, mission-critical connectivity was only considered necessary in key segments such as defense, emergency services, healthcare, financial services, etc. But today every household's connection is critical. People increasingly depend on broadband for their basic needs. Service interruption today isn't limited to being unable to download a movie (annoying). It is a question of not being able to work, attend lessons, get online assistance, etc. (critical).

Fiber is already robust and very resistant to outside factors (water, corrosion) and also electromagnetic disturbance, which is an important advantage over wireless or copper wiring in industrial environments. An industrial machine in a heavy electromagnetic environment, for example, would render wireless or copper connectivity unusable; fiber doesn't even blink.

At the same time, new approaches have made network electronics more reliable. Features are implemented on smaller, discrete hardware components that are in-field replaceable. Software changes and upgrades can be made without interrupting services. Artificial intelligence and predictive care ensure that network issues are solved before affecting services. All these features now bring six nines reliability to PON fiber broadband.

Latency

Sub-1ms latency is of increasing importance for a growing number of applications. Industry 4.0 has brought a wave of innovations that depend on both high-speed connectivity and low latency: applications in the cloud for analytics and real-time decision making, machine automation, and robotics, to name just a few. 5G fronthaul also requires low latency, especially when 5G is used for applications like autonomous vehicles. Even consumer apps like gaming need low latency. Recent advances mean that PON can deliver the low latency required by all these applications:

• CTI (cooperative transport interface) ensures communication between the mobile traffic scheduler and OLT is flawless; it introduces a state of readiness for mobile traffic into the PON network so that it is handled without any delay.

• Multiple bursts in a frame ensure that the queuing delay in the ONT is cut by a factor of four.

Security

To be successful in offering business services, security is key. As a shared medium, PON uses multiple methods to separate, encrypt and secure data on the network. For example, standard features include procedures to:

- Isolate traffic for each user, so users on a PON cannot access data that is not intended for them.
- Encrypt data traffic, so data cannot be read by other users.
- Prevent an attempt to connect an unauthorized device (e.g., a malicious ONT, reflective splitter, or listening device).
- Validate control messages, and make sure they come from a legitimate source and that they have not been edited.

These methods provide mission critical security on a par with dedicated point-to-point fiber connections and enable operators to serve their business customers much more efficiently on a PON.

Energy efficiency

Fiber PON is the greenest way to deliver broadband. Over the last 15 years or so, fiber has enabled broadband network power consumption to be reduced by 38% while broadband speeds have increased by a factor of 64. The capacity of a fiber PON network can absorb the traffic of multiple networks without the associated increase in energy consumption, so the more networks are replaced by fiber, the better it is for the environment. Having multiple services running on a single fiber network is way more power efficient than having separate parallel networks, where each network has its own equipment (or even outside plant) that needs to be powered. The scalability, reliability and longevity of fiber also contribute to a lower carbon footprint as fiber requires less maintenance and fewer repairs.

Winners and winners

It is difficult to find arguments against a Fiber for Everything approach. From an individual customer to the entire planet, everyone comes out ahead.

Operators

By using the same fiber for multiple services, network operators create more revenue streams, which accelerates payback and maximizes return on investment. Every new PON technology can be overlaid on the same fiber with very little additional cost, without touching the expensive passive (and often even the active) components of the network. Once deployed, the fiber outside plant can be used for 75+ years.

PON is also far simpler and cheaper to scale than point-to-point fiber as new connections are added from the nearest splitter rather than all the way from the central office. Incremental scaling and investments in new PON technologies lead to further revenues, especially with services that combine high bitrates, low latency, and green connectivity.

A single converged network is, of course, cheaper to operate than multiple parallel networks, leading to a significantly lower CAPEX and OPEX. Here are few examples:

- 30% lower TCO to connect business customers (compared to point-to-point fiber),
- 40% lower power consumption, significantly contribution towards an operator's sustainability targets.
- 50% lower TCO for mobile anyhaul (compared to point-to-point and microwave).

Customers, economies and societies

The superior business case of a Fiber for Everything approach makes fiber a more compelling investment opportunity, which is attracting new entrants and new forms of finance, which are in turn accelerating fiber deployments and helping close the digital divide. This is particularly interesting for governments in rural areas, where lack of broadband has a negative effect on society and economy. These deployments are bringing life-enhancing broadband to more consumers and businesses and the superior capacity of fiber enables new innovative services.

The planet

The ICT industry today accounts for more than 2% of global greenhouse gas emissions, about the same as all air traffic. However, ICT technologies have the opportunity to help other industries become more sustainable. Digitalization in general and broadband in particular contribute by cutting transportation, creating gains in productivity, efficiency, and boosting economic growth for individuals, countries, cities, and society as a whole. So, despite its own carbon footprint, ICT actually carries a 7-fold net positive effect, reducing global CO_2 emissions by up to 15%.

These savings are all the more important when we consider the inexorable demand for connectivity. Half the world's population still does not have access to reliable fixed broadband while the number of connected devices is growing exponentially. Add to this demand the global deployments of 5G with dense networks of small cells all requiring transport and it is clear that a Fiber for Everything approach that connects more people and services while simultaneously lowering its own power consumption magnifies the positive effect on our planet.

Conclusion

Fiber broadband is a fantastic opportunity, and the business case for it is getting even stronger. With fiber being available almost everywhere, operators have started to ask themselves: what else can I do with fiber? What additional services can I offer? How can I generate more revenues? How can I create more synergies that will benefit other parts of my network?

PON technology has evolved to meet enterprise access and 5G transport networking requirements while supporting easy upgrades and the coexistence of multiple technologies so that every service can be delivered in the most efficient way on the same fiber. Network slicing enables each service to have the QoS it needs and to be managed independently while SDAN removes the complexity of the resulting multi-service, multi-technology environment. The financial rewards are more revenues and lower costs to serve.

Many operators worldwide have already made the shift and taken a Fiber for Everything approach: Chorus, CityFibre, and Frontier, just to mention few, are using their fiber networks to serve both residential and business users. Others, like STC, are using their existing PON network for 5G transport.

And with the evolution to 25G PON, which has been trialed by ATT, TIM, OpenReach and many others, even more opportunities are becoming a reality.

Abbreviations

AES	Advanced Encryption Standard
BPON	Broadband passive optical network
CTI	Cooperative transport interface
EPON	Ethernet passive optical network
FTTH	Fiber-to-the-home
GEM	Gigabit Encapsulation Method
GPON	Gigabit passive optical network
ICT	Information and communications technology
MIC	Message integrity checks
OLT	Optical line terminal
ONT	Optical network terminal
OPEX	Operating expenditure
OTT	Over-the-top
PON	Passive optical network
ROI	Return on investment
SDAN	Software-defined access networking
SDN	Software-defined networking
SLA	Service level agreement
TCO	Total cost of ownership
QoS	Quality of service
XGS-PON	10 Gigabit symmetrical passive optical network