LANCOM SYSTEMS

White Paper

Broadband expansion with fiber optics

The expansion and modernization of high-performance Gigabit telecommunications networks is ongoing. The intention is to take fast, reliable Internet to as many households, businesses, and public institutions as possible. Broadband provision refers to Internet access with at least 50 Mbps. Although around 93 percent of households in Germany already have these speeds, broadband expansion remains a patchwork[1]. In parallel with the optimization of existing copper connections through faster DSL technologies and the DOCSIS cable Internet, fiber-optic connections come as different variants. In addition to GPON, AON and G.fast, now in the starting blocks is XGS-PON, the latest broadband network standard for 10 Gbps. It is also important to check exactly what type of connection is available at the respective location.

This White Paper describes the latest broadband connections and outlines their advantages and technical differences. The information provided helps to select the best connection router for any particular application.

Fiber optics for house connections (FTTH / FTTB)

Fiber optics are a key element for expanding the broadband Internet. The technology offers almost unlimited bandwidth capacity and extremely low signal attenuation. This makes fiber optics ideal for transmitting large amounts of data over long distances.

Here we discuss two different types of house connection:

- → **FTTH (Fiber to the Home)**: In this instance the fiber-optic cabling is routed to the individual apartment or company building. The hand-over point between the telecoms provider FTTH network and the customer's home network is equipped with an Optical Network Terminal (ONT), which converts the electrical signal from the house network into a fiber-optic signal for transmission to the Optical Line Terminal (OLT). An optical splitter delivers the optical signals from the ONTs to the OLT in a combined light beam .
  FTTH uses three different access technologies that use fiber optics as a transmission medium, but which offer different properties and functionality; namely **GPON**, **XGS-PON** and **AON** (also known as Active Ethernet).
- → **FTTB (Fiber to the Building)**: This is where the fiber optics enter the building. Here they generally terminate at a hand-over point that transfers the fiber optics into the copper-based house network. The residential / company units in the building thus share the bandwidth arriving over the fiber optics.

[1] www.deutschlandatlas.bund.de/DE/Karten/Wie-wir-uns-vernetzen/090-Breitbandversorgung.html from August 22, 2024

Structure of fiber-optic cable

Glass fibers act as an optical waveguide. In contrast to DSL connections, the signals are not transmitted electrically, but optically using pulsed light. Transmission speeds within the fiber are extremely fast at 2/3 the speed of light.

A fiber-optic cable is made up of four components; the core, the cladding, the buffer, and the outer jacket.

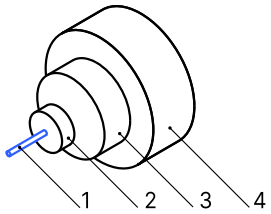

Figure 1:
Structure of fiber-optic cable

a) The core (1) is as thin as a human hair and transmits the signals.
b) The cladding (2) helps to guide the light by preventing it from leaving the fiber.
c) The buffer (3) and the outer jacket (4) serve as protection from mechanical damage.

Architectures for FTTH fiber-optic networks

There are currently three technologies for providing broadband services:

GPON

A Gigabit Passive Optical Network (GPON) is a shared medium, comparable to a cable network. The optical fibers from several households are aggregated by a passive optical splitter and share the same line to the network operator.

Each network operator line provides a data rate of 2.5 Gbps for download and 1.25 Gbps for upload. This capacity has to be shared between the connected households. This is known as the splitting factor. A typical splitting factor in Germany, for example, would be 1 in 32. 32 households thus share the data rate of a single GPON connection.

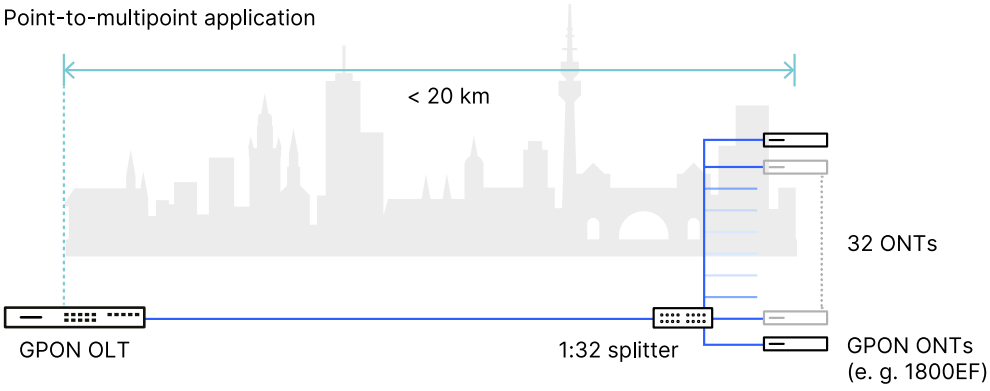

Figure 2:
Gigabit Passive Optical Network (GPON)

GPON uses dynamic bandwidth allocation and various quality-of-service functions to ensure that users still enjoy the best possible performance despite sharing their bandwidth. The primary advantages of GPON for the network operator are that fewer optical fibers need to be laid and the port density at the exchange is higher. A single port can be used to connect many subscribers, which has a cost advantage.

XGS-PON

The 10 Gigabit Symmetric Passive Optical Network, or XGS-PON for short, is a further development of GPON. It offers symmetrical transmission rates of 10 Gbps, meaning that the upload and download speeds are the same and ideal for demanding applications.

To do this, XGS-PON uses a combination of time division multiplexing (TDM) and wavelength division multiplexing (WDM) to transmit multiple data streams over the same fiber. The downstream data is transmitted at a wavelength of 1577 nm, while the upstream data is sent at 1270 nm. The 10 Gbps transmission rate supports more broadband-intensive applications than GPON, including 8K streaming, cloud computing, and virtual reality.

The transition to XGS-PON requires not only the implementation of new optical network infrastructures, but also changes to the end devices, especially routers, used in homes and businesses. An XGS-PON-capable router is an essential component to fully exploit the high data rates and symmetric bandwidth that XGS-PON offers.

Since XGS-PON is not backwards compatible with GPON, this means that existing GPON routers will not be able to work with the new standard. The purchase of an XGS-PON-capable router is therefore unavoidable. These routers are designed to support both the higher bandwidth and the new technical requirements that come with XGS-PON, such as better network utilization, lower latency, and a more stable connection at higher speeds.

A typical splitting factor in Germany, for example, would be 1 in 64. However, some systems and scenarios may support higher splitting ratios, such as 1:128. This depends on the specific data-rate requirements and the transmission distance.

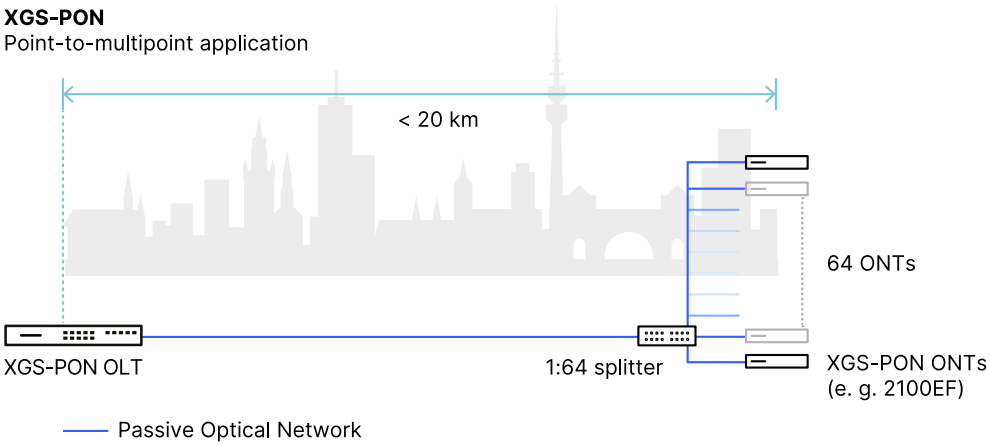

Figure 3:
10 Gigabit Symmetric Passive Optical Network (XGS-PON)

AON

Active Optical Networks (AON) or Active Ethernet are point-to-point connections between the subscriber and the network operator. Each subscriber has a separate line to the network operator's exchange, also known as PoP or CO. As a rule, Ethernet is used as the transmission protocol and offers a symmetrical speed of 1 Gbps for downloading and uploading

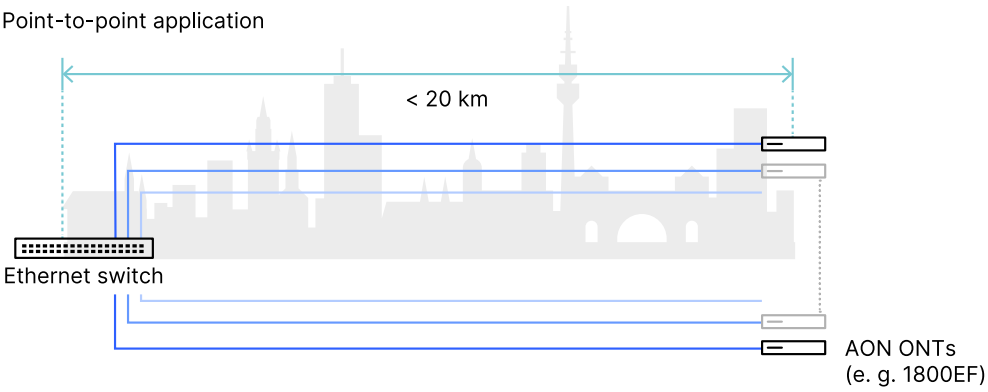

Figure 4:
Active Optical Network (AON)

The advantage of AON is that the data rate is not shared with other subscribers and each user benefits from guaranteed performance. Consequently, every customer has the full bandwidth available at all times—even at peak periods. Furthermore, having a separate line makes it less susceptible to interference. The strengths of Active Ethernet are thus particularly advantageous for business applications.

Overview of GPON, XGS-PON and AON

Properties	GPON	XGS-PON	AON
Connection mode	Point-to-multipoint application	Point-to-multipoint application	Point-to-point application
Bandwidth	2.5 Gbps downstream, 1.25 Gbps upstream	Symmetrical 10 Gbps in downstream and upstream	Depends on the transmission technology used. Usually 1 or 10 Gigabit Ethernet.
Typical splitting factor	1:32	1:64	– (each device has its own line)
Advantages	Cost-effective, widely used, easily scalable → established standard	Future-proof bandwidth for downstream and upstream	Undivided bandwidth → low latency and consistent performance
Disadvantages	Shared and asymmetric bandwidth, which may not be sufficient for high-performance applications	More expensive network components	Higher costs for installation, maintenance and power consumption

G.fast for FTTB fiber-optic networks

Instead of laying fiber optics to every household, FTTB terminates the fiber optics in a service connection room that may be in the basement, or in the immediate vicinity of the building. From here, the final few meters to the subscriber are often bridged by the copper twin-core wiring of the existing telephone cables.

The transmission technology is G.fast, a DSL-based technology that is optimized for transmission over short distances. This enables data rates of over 1 Gbps for each subscriber. The data rates are higher than (V)DSL as a much larger frequency spectrum is used. A result of this is that the data rate decreases rapidly with increasing line length due to the strong attenuation in the copper wire pair.

The advantage of FTTB in combination with G.fast is that you can reuse the subscriber's existing infrastructure without having to accept speed deficits. The initial costs are low and the network can be expanded rapidly. This makes G.fast an ideal bridging technology.

Conclusion

The massive drive in Germany to expand the availability of broadband is leading, on the one hand, to a significant improvement in connection speeds and, on the other hand, to an increasing variety of connection types. When selecting a suitable Internet access router it is important to check which fiber-optic connection is or will be available at the respective location.

Those companies requiring higher bandwidths should look to professional network equipment manufacturers with router portfolios that reflect every type of connection. Ideally, these devices should also be able to operate several of the Internet connections available at the respective location in parallel. This has two advantages: In active / active mode (load balancing), the bandwidth of several connections can be used at the same time, and if one of the lines fails, the connection to the Internet remains intact (i.e. high availability).

Despite the strong growth seen in recent years, rural areas still have some catching up to do. An alternative solution could be the 5G mobile communications standard. The great advantage of expanding cellular networks compared to wired networks is the simplified access to households. There is no need for construction work to lay fiber optics or cables or to install service access to houses and apartments. A single radio mast provides access for hundreds of subscribers. For more information on 5G technology, see our White Paper or the LANCOM Technology website.

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