

White Paper

Fiber-optic speed throughout the home – without new cabling

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devolo AG and its product history

devolo AG, the technology company from Aachen, Germany, has focused on PLC technology (PowerLine Communications) since the company's founding in 2002. The company's first products were pure PLC solutions that distributed the Internet signal from the router

The PHY rate refers to the speed of the physical layer. This is the maximum possible speed at which data can be transmitted. Thus, the Internet connection goes from the NT (Network Termination)/ONT (Optical Network Termination) to the router without the effort and

“Now the technology company's portfolio has been expanded to support fiber-optic deployments[...].”

throughout the entire home over the existing electric power supply lines. The current products from the devolo Magic series also rely on the Powerline backbone (PLC) in accordance with ITU-T G.9960 standard (G.hn), which is particularly advantageous in combination with mesh Wi-Fi. Now the technology company's portfolio has been expanded to support fiber-optic deployments, which transmit the Internet signal over existing, unused coaxial (SAT/TV) or telephone lines and thereby create a high-speed, point-to-point connection with a PHY rate of up to 2 Gbps.

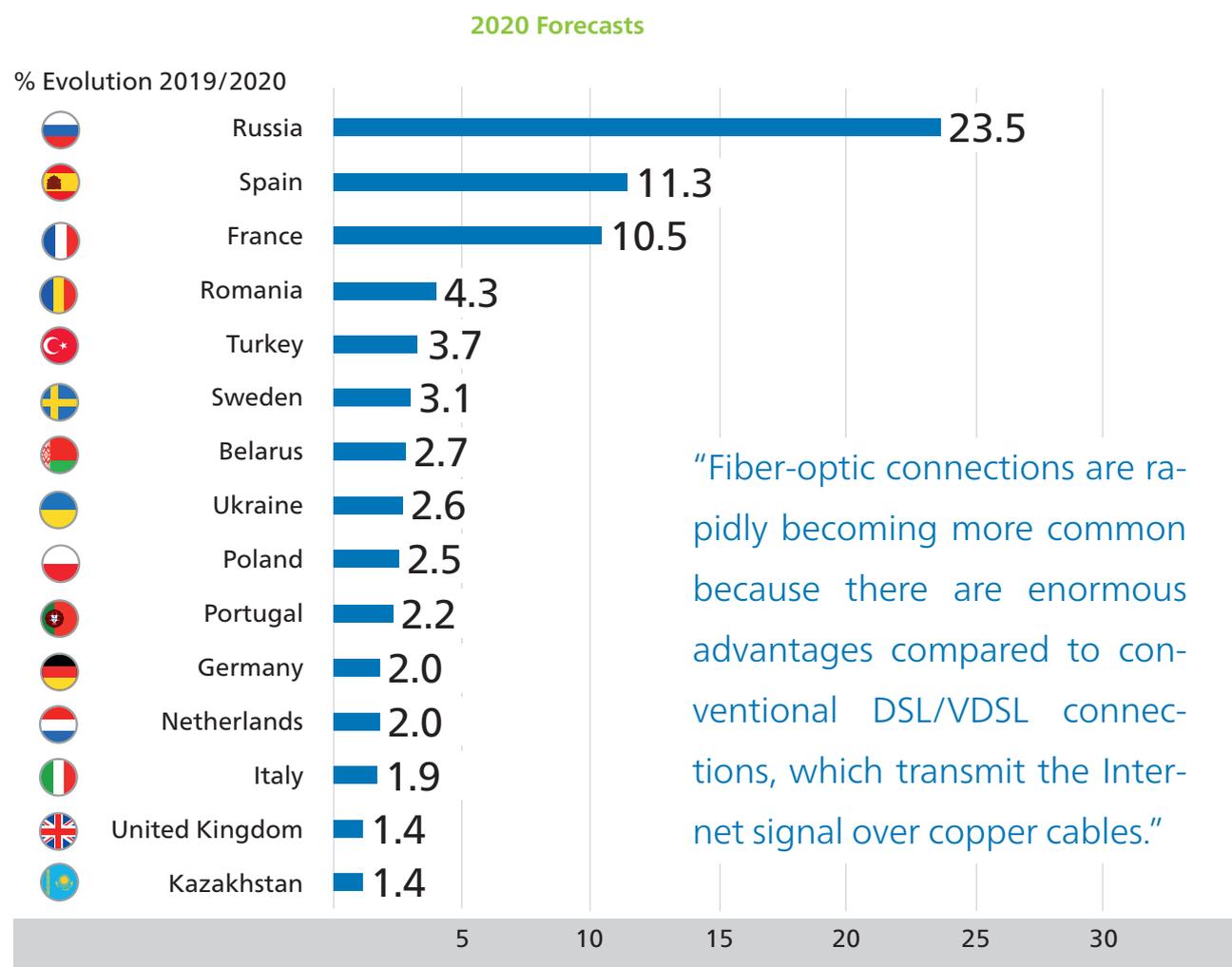
costs of laying new network cables or the problem of the router being poorly positioned in a basement, garage or service entrance room. The following pages explain the enormous advantages of these new fiber-optic products compared to expensive and complicated cabling, provide more details on how the products function and show how fast fiber-optic Internet can benefit from the technology used.

1. Fiber-optic – the Internet of the future

Fiber-optic connections are rapidly becoming more common because there are enormous advantages compared to conventional DSL/VDSL connections, which transmit the Internet signal over copper cables. For one thing, it is considerably easier to lay new fiber-optic cables – despite their higher sensitivity – than copper cables, since empty pipes with a smaller diameter can be used. Fiber optics have made large, long-term construction sites and the associated deep pits a thing of the past.

Another advantage of fiber optics, particularly due to continuously advancing digitalisation, is the speed. Currently (as of May 2021), residential fiber optics can be used to transmit up to 1 Gbps (symmetric for download and upload), whereas the speed with DSL is, in most cases, only a max. of 250 Mbps for download and 50 Mbps for upload. One exception here is G.fast, which is also based on the Supervec-toring transmission method, and which transmits signals over conventional copper telephone cables.

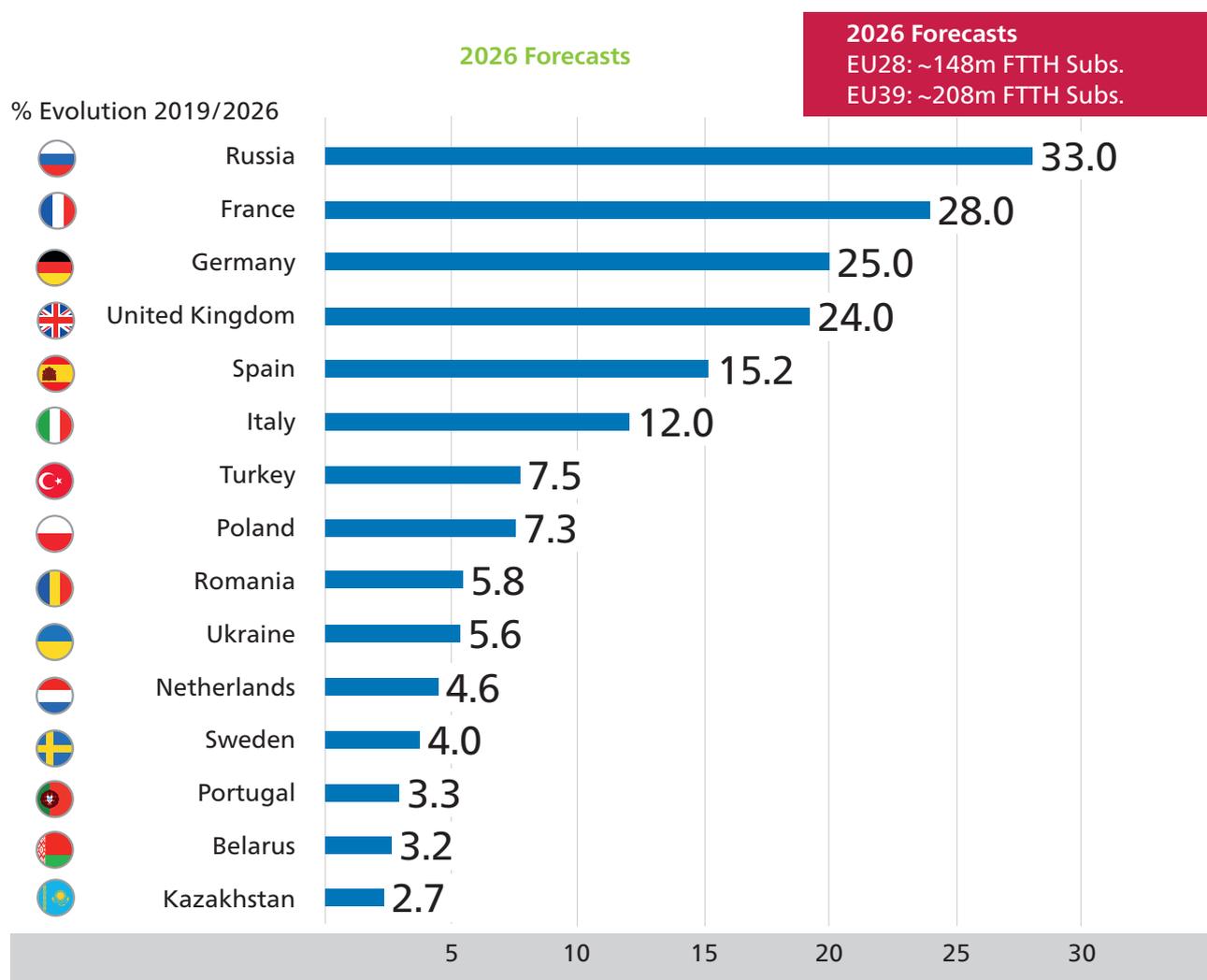
European ranking in terms of FTTH/B Subscriptions (million)



Source: IDATE for FTTH Council EUROPE

1. Fiber-optic – the Internet of the future

European ranking in terms of FTTH/B Subscriptions (million)



Source: IDATE for FTTH Council EUROPE

However, the disadvantages of this technology are its high susceptibility to crosstalk as well as high frequencies (up to 212 MHz) over long distances. Here, it is typical to have connections running in parallel over a distance of 250 metres, which results in signal attenuation.

For these reasons, the transmission rates only reach up to 1 Gbps (total for transmitting and receiving directions) for line lengths up to a max. of 100 metres. In the case of doubled cable lengths of 200 metres, the transmission rate drops to a mere 200 Mbps.

1.1 Comparison of DSL, VDSL, cables and fiber optics

Internet connection	Implementation	Max. speed (Mbps)	Availability
DSL/VDSL2 (G.fast)	Over the telephone line	Up to 250 max., asymmetric, only in download (up to 1000 max., for end customers approx. 300 to 500)	Very high
Coaxial cables	Over the TV cable socket	Up to 1000 max	Medium
Fiber optics	Fiber-optic cables	Up to 1000 max. (technically already up to 10,000 max., symmetric)	Low to medium, sharply rising trend

“The future clearly belongs to fiber-optic Internet. Yet despite the numerous advantages of fiber optics compared to conventional DSL/VDSL solutions, the installation and set-up within one’s own home is considerably more difficult than previously assumed and frequently requires costly and time-consuming renovation work.”

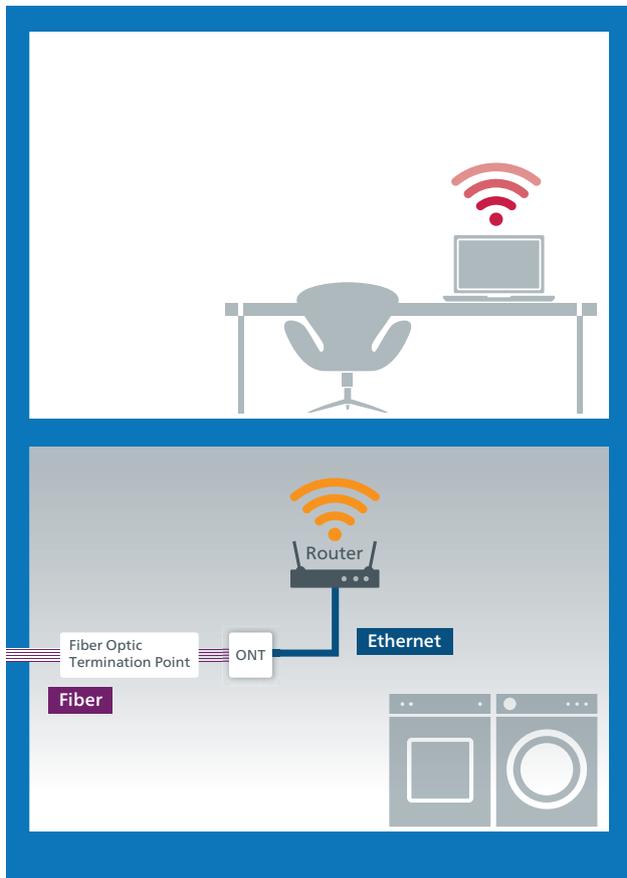
1.2 Fiber-optic architectures

FTTH - Fiber to the Home:
“Fiber-optic cabling runs up to the connection socket in the home without using other media.”

Architecture	Meaning of abbreviation	Description
FTTC	Fiber to the Curb	Fiber-optic cabling runs from the main distribution point of the provider to the local distribution cabinet at the curbside. Further data transmission occurs over telephone cables.
FTTdp	Fiber to the distribution point	Fiber-optic cabling runs from the main distribution point of the provider to the distribution street cabinet. Further data transmission occurs over telephone cables.
FTTB	Fiber to the Building	Fiber-optic cabling runs into the house or termination point. The final metres up to the Internet router/terminal device are handled by phone or network cables.
FTTH	Fiber to the Home	Fiber-optic cabling runs up to the fiber optic outlet in the home without using other media.

2. Connection issues

For many fiber-optic providers, the connection ends at the subscriber delivery point, which is the termination point of the provider's Internet access. In order to minimize the costs of cabling, the cables are laid on the shortest path and end behind the first houses wall. This is often located in a basement, service entrance room or garage. After this point, the fiber-optic signals are transmitted to either a passive or active NT (Network Termination)/ONT (Optical Network Termination). The customer has no say in the selection of a corresponding device because the provider decides whether an active or passive NT/ONT is used.



Starting point: FTTH architecture and the fiber-optic connection from the Fiber Optic Termination Point (left) to the active NT/ONT (right); Source: devolo AG

The differences between active and passive terminations lie in the power supply and functionality. An active NT/ONT has a power connection and an integrated modem. An Ethernet connection to the WAN port of the Internet router can be established via the RJ45 outlet. By contrast, a passive NT/ONT has no integrated fiber-optic modem; accordingly, there is no conversion of the signals from light pulses to electric signals. An additional device, such as a fiber-optic modem or fiber-optic router, has to be connected so that the fiber-optic signal can be connected to the home network.

2.1 Placement of the router

Once the fiber-optic connection has been successfully connected to the subscriber delivery point, the next step is to find the optimal place for the active NT/ONT and router. Often the NT/ONT is placed right next to the subscriber delivery point, so the two devices can be easily connected to each other. It is significantly more difficult to make the following connection between the NT/ONT and router, because many customers know that the correct router placement plays an important role.

After all, the new high-speed Internet is supposed to reach the terminal devices (e.g. smartphone, tablet, smart TV, laptop and game console) at full speed. This is why most households have the router located in either the living room or a hallway. The purpose of this is to achieve the best possible Wi-Fi signal coverage.

2.2 Cabling between the NT/ONT and router

The NT/ONT and router are connected exclusively by network cables with an RJ45 connector; often large distances need to be bridged for this purpose. So, when providing cabling, customers have to pay attention to the technical conditions of the available network cables. Depending on the distance that needs to be covered from the NT/ONT to the router or a corresponding terminal device, there are a few pitfalls. Fixed network cables, which lead to mains sockets, for example, are allowed to have a maximum distance of 100 metres. If the distance is expanded beyond that, it is not compliant with Ethernet connection standards and will lead to high attenuation of the cable as well as latency (delay from the transmitter to receiver), which has a significant effect on the data transmission and cancels out the advantage of gigabit Internet. If it is still necessary to cover long distances in the house, then customers have to use intermediate repeaters. Here, however, it must be observed that, depending on the circuit,

five to ten metres have to be subtracted from the maximum cable length. So having clean, optimal cabling for a new fiber-optic connection is not exactly trivial and requires good preparation. In the case of laying cable between the subscriber delivery point and a passive NT/ONT, the set-

“So having clean, optimal cabling for a new fiber-optic connection is not exactly trivial and requires good preparation.”

up is even more complex. Here, the connection is made with sensitive fiber-optic cables. In the case of a new building, additional empty pipes are planned for this purpose, but in the case of existing older houses, such empty pipes are not likely to be available. These installations can be either hidden (flush-mounted) or visible (surface-mounted), e.g. by means of cable ducts.

2.3 Overview of cabling classes

Category	Frequency (MHz)	Data rates	Range (in metres)	Cabling class
Cat 5e	Up to 100	Up to 1 Gbps	100	D (RJ45)
Cat 6	Up to 250	Up to 1 Gbps	100	E (RJ45)
Cat 6A	Up to 500	Up to 10 Gbps	100	Ea (RJ45)
Cat 7	Up to 600	Up to 10 Gbps	100	F
Cat 7A	Up to 1000	Up to 10/40/100 Gbps	100/50/15	Fa

3. The solution: devolo Giga Bridge



With the devolo Giga Bridge, customers can use their fiber-optic connection at higher speeds without having to do any renovation; Source: devolo AG

“The aforementioned problems of a new network cable installation mean additional effort and costs, but the Giga Bridge from devolo provides a solution. It uses the G.hn standard to bridge the gap between the NT/ONT and router or terminal device by using the home’s existing coaxial line (SAT/TV) or telephone line.”

3. The solution: devolo Giga Bridge



The aforementioned problems of a new network cable installation mean additional effort and costs, but the Giga Bridge from devolo provides a solution. It uses the G.hn standard to bridge the gap between the NT/ONT and router or terminal device by using the home's existing coaxial line (SAT/TV) or telephone line. The devolo Giga Bridge uses this cabling to build a high-speed point-to-point connection with a data rate of up to 1 Gbps, allowing the full potential of the fiber-optic connection to be used without the burden of installing new cables.

The devolo Giga Bridge is equipped with:

1. one gigabit network connection (ETH)

for the connection from the NT/ONT to the devolo Giga Bridge and from the devolo Giga Bridge to the router (extension of the Ethernet WAN connection)

or

for the connection from the router to the devolo Giga Bridge and from the devolo Giga Bridge to a device with an Ethernet port (extension of the in-home LAN coverage)

2. one G.hn phone port for connection to the telephone line (phone)

3. one F-connector for connection to the coaxial line (75 ohm)

4. one LED indicator

5. one reset button (next to the network connection).

devolo Giga Bridge

3.1 What exactly is G.hn?

G.hn is a technical standard developed by the International Telecommunication Union (ITU) and supported by numerous organisations, including the HomeGrid Forum industrial association.

3.2 Advantages of coaxial and telephony cabling compared to PLC

	Coaxial/ telephone cables	PLC
Susceptibility to interference (step impedances in the network)	Does not exist, because the medium is used exclusively. In addition, the cabling for these media is constant.	Medium, because the power line is not used exclusively. Connected consumers (e.g. household appliances) cause transmission interference.
Structure of the cabling	Point-to-point connection	Shared medium in a star configuration
Availability in households*	Telephone wiring: 99% SAT cabling: 45% TV cabling: 75%	Power sockets: 100%
Speed in the home network (for distances of 40 metres)	Gigabit, because the signal transmission is lossless.	Max. of 250 Mbps, depending on the power line and connected devices.
Installation	Easy	Very easy

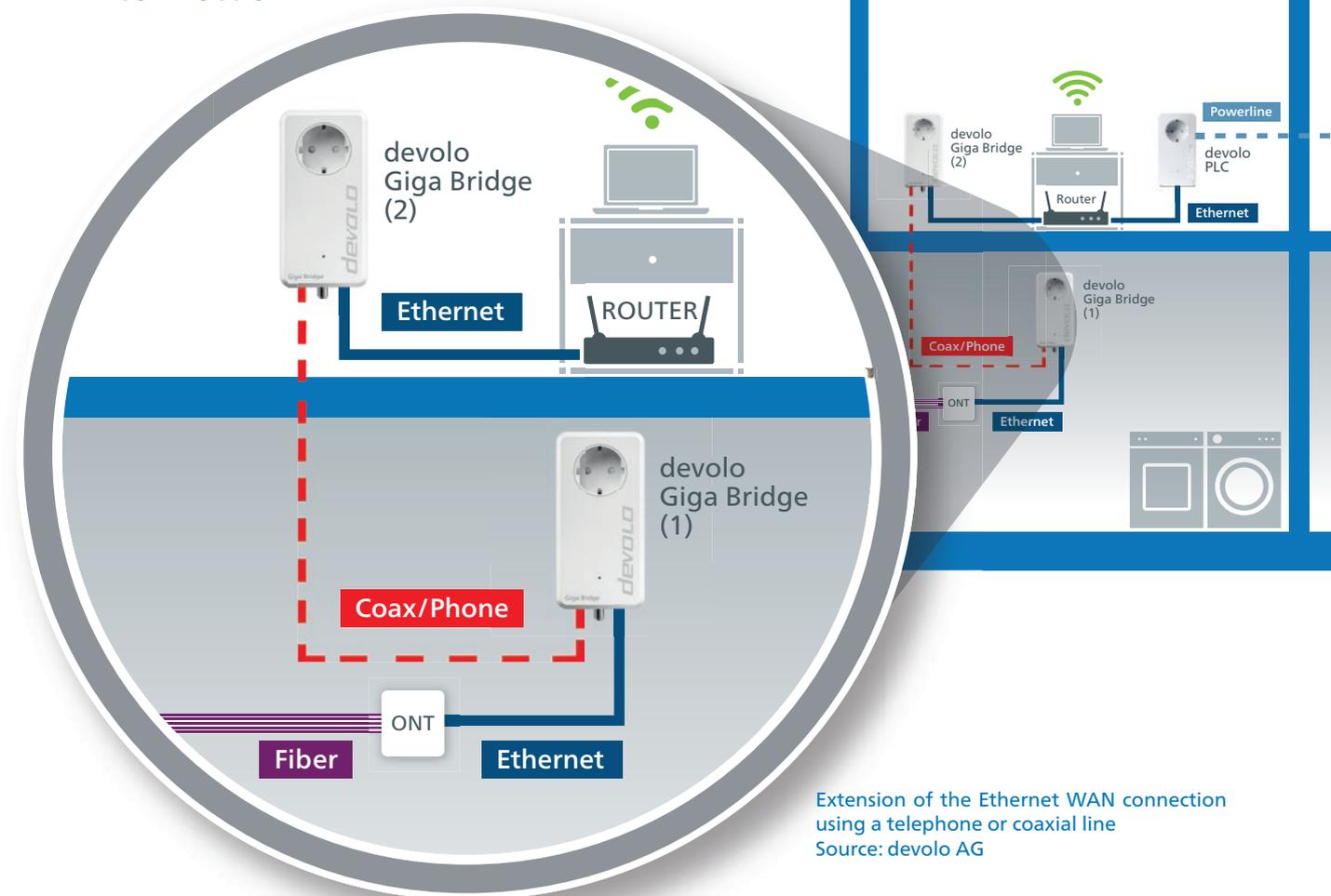
*Source: German Federal Office of Statistics

3.3 Possible applications of devolo Giga Bridge

Extension of the Ethernet WAN connection using a telephone line

In this scenario, the G.hn signal is transmitted over two or four telephone wires between the NT/ONT and router at a data rate of up to 1 Gbps. The achieved speed of up to 1 Gbps is the net data rate, which is reached during transmission from the NT/ONT to the router. In the case of two telephone wires, SISO mode is used. In MIMO mode, all four wires are used as two pairs. MIMO mode is recommended only for long distances exceeding 100 metres. For shorter distances, MIMO transmission does not provide any higher data rates.

Extension of the Ethernet WAN connection



Extension of the Ethernet WAN connection using a coaxial line

In this scenario, the G.hn signal is transmitted over a standard coaxial cable between the NT/ONT and the router at a data rate of up to 1 Gbps. Only SISO mode can be used. Due to the high RF performance of coaxial cables and the very high grade of insulation, long distances of several hundred metres can be bridged at data rates of up to 1 Gbps.

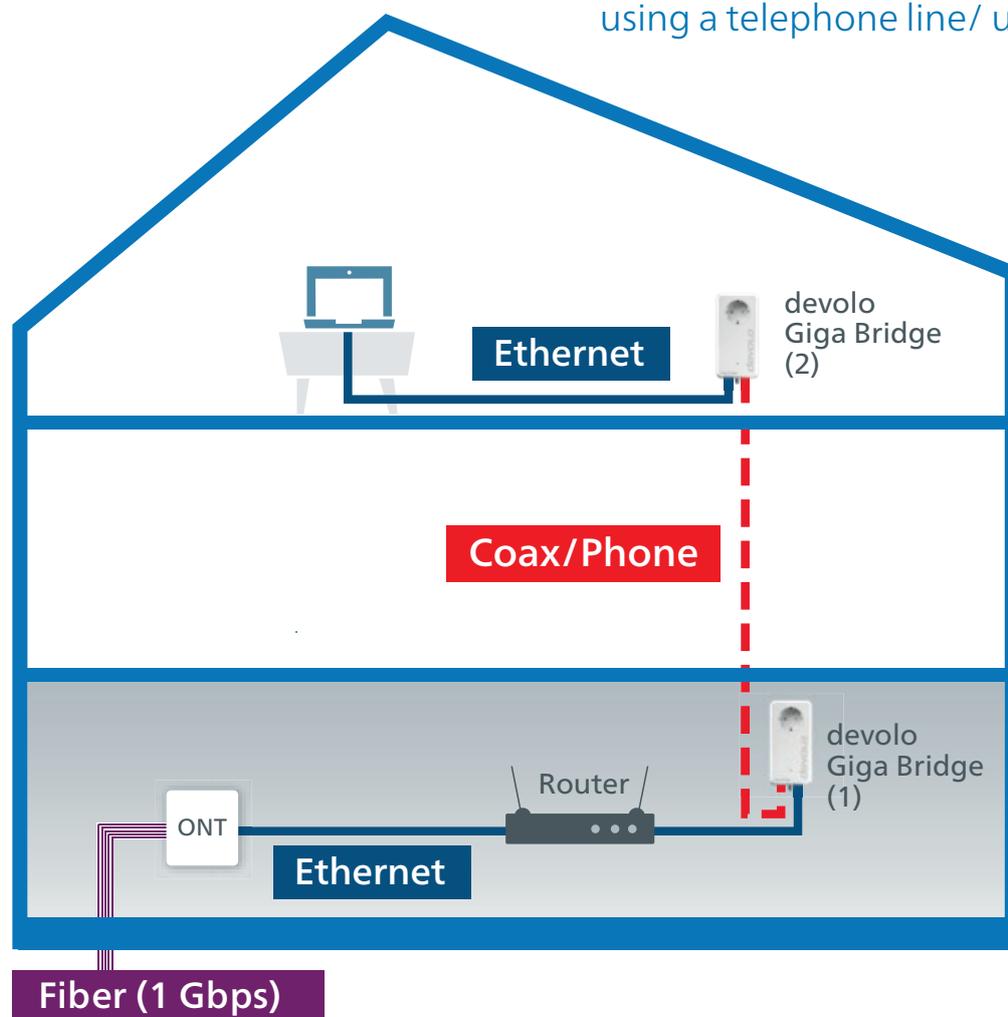
Extension of the in-home LAN coverage using a telephone line

In this scenario, the G.hn signal is transmitted over two or four telephone wires between the router and another LAN device with an Ethernet port at a data rate of up to 1 Gbps. In the case of two telephone wires, SISO mode is used. In MIMO mode, all four wires are used as two pairs. MIMO mode is recommended only for long distances exceeding 100 metres. For shorter distances, MIMO transmission does not provide any higher data rates.

Extension of the in-home LAN coverage using a coaxial line

In this scenario, the G.hn signal is transmitted over a standard coaxial cable between the router and another LAN device with an Ethernet port at a data rate of up to 1 Gbps. Only SISO mode can be used. Due to the high RF performance of coaxial cables and the very high grade of insulation, long distances of several hundred metres can be bridged at data rates of up to 1 Gbps.

Extension of the in-home LAN coverage using a telephone line/ using a coaxial line



Extension of the in-home LAN coverage using a telephone or coaxial line
Source: devolo AG

3.4 Difference between SISO and MIMO mode

	Telephone line	Coaxial line
SISO Single Input Single Output	Here, two telephone wires are used. The speed between the NT/ONT and router can reach up to 1 Gbps and the range can be up to 100 metres.	Coaxial cables have a very high grade of insulation and high RF (radio-frequency) performance. The speed between the ONT and router can reach up to 1 Gbps and the range can be up to several hundreds of metres.
MIMO Multiple Input Multiple Output	Here, all four telephone wires are used as pairs. The speed between the router and another LAN device with an Ethernet port can reach up to 1 Gbps and the range can be more than 100 metres.	

3.5 Cabling between the devolo Giga Bridge and the NT/ONT

As already mentioned, the NT/ONT and devolo Giga Bridge can be connected via Ethernet patch cord. The patch cable should be suitable for the high data rate of up to 1 Gbps.

3.5.1 Coaxial TV cable

Using a coaxial cable with an F-connector is probably the easiest option for connecting to the Giga Bridge. Simply remove a cable from the coaxial distributor and then plug the end of the cable (F-connector) into the devolo Giga Bridge, tighten it and you're done.

3.5.2 Telephone cable (phone line)

In most cases, there is no phone jack outlet near the demarcation point. This means that here, for example, a network jack with an IDC terminal has to be used to connect the existing telephone wiring to the G.hn phone port of the devolo Giga Bridge. The telephone cable is removed from the demarcation point and then split and contacted by means of connection technology involving wire stripping and soldering or screwing down. A standard network interface is created as a result. Then a classic network patch cord (Cat 5e or higher) can be used to establish a connection to the devolo Giga Bridge (phone).



The telephone cable that used to be in the demarcation point is first removed and then split and contacted to turn it into a standard network interface. Now the devolo Giga Bridge can be connected to the NT/ONT using a network patch cord (phone)
Source: devolo AG

3.6 Cabling between the devolo Giga Bridge and the router

Once the first devolo Giga Bridge adapter has been connected to the NT/ONT, the second devolo Giga Bridge adapter has to be connected to the router in the living space as the next step. After the adapter is plugged into an available power socket, depending on the type of cabling selected, it is connected using a coaxial or telephone cable. For this purpose, the corresponding cable has to be connected to the socket provided for this.



The second devolo Giga Bridge adapter is connected to the router in the living space using a coaxial (Coax) or telephone cable (phone) depending on the type of cabling selected; Source: devolo AG

3.6.1 Coaxial TV cable

Using a coaxial cable with an F-connector is convenient, since no other cabling is required. Simply take the existing SAT and TV connection cable that you are no longer using and plug it into the antenna outlet. Plug the other end of the cable (F-connector) into the devolo Giga Bridge, tighten it and you're done.



An adapter turns an F-outlet into a compatible coaxial connection
Source: devolo AG

If a coaxial cable is used to connect to the devolo Giga Bridge, then typical adapters and connectors can also be used. For example, if an F-outlet and existing coaxial lines are to be converted into a compatible coaxial connection, an F-connector to coaxial connector is recommended.

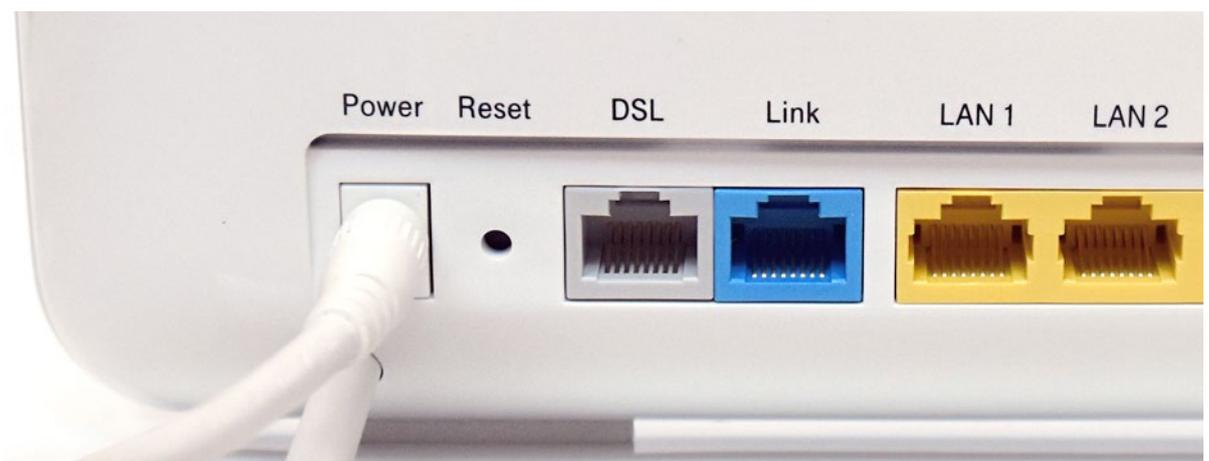
3.6.2 Telephone cable (phone line)

Using a telephone cable for the connection is also easy. If there is an unused telephone outlet (TAE outlet, Telecommunication Adapter Equipment) and an old telephone connection cable, e.g. a grey DSL cable, it can be easily connected to the G.hn phone port of the devolo Giga Bridge. The DSL cable uses the same wire pair assignment (central pins, 4/5 and 3/6) as the devolo Giga Bridge, so no further steps are required.



An F-coded TAE outlet and a conventional telephone cable are enough to connect the devolo Giga Bridge to the NT/ONT. The TAE connector uses pins 1/2, which means the Giga Bridge's SISO mode is used. ; Source: devolo AG

The Giga Bridge adapter and router are connected by a network patch cord. For this purpose, one end of the patch cord is connected to the gigabit network port of the devolo Giga Bridge (ETH) and the other end is connected to the WAN port (Wide Area Network/Link) of the router.



Some manufacturers (here, the Speedport W724 V Typ A from Deutsche Telekom) have made the WAN port (Link) of their router blue to set it apart from the conventional RJ45 port (yellow). Some routers have no separate WAN port. In that case, it is integrated into the RJ45 ports and can be configured by the user. ; Source: devolo AG

4. Advantages for providers and customers

When the devolo Giga Bridge is used for the cabling between the NT/ONT and router, it yields enormous cost and time savings for both providers and customers. As already mentioned in the Connection issues chapter, conclusion of a contract with a fiber-optic provider includes only the laying of fiber-optic cables to the subscriber delivery point and to the NT/ONT.

In most cases, the end customer has to establish the connection between the NT/ONT and router (provided that the router is not going to be placed in an inconvenient location such as a basement, utility room or garage). This requires renovation measures that allow the Ethernet or fiber-optic cables to be laid cleanly: either hidden flush-mounted installations or surface-mounted installations that include empty pipes. Alternatively, providers also offer installation services at an extra charge. When this is done, however, often only a few metres (up to 20 metres) of Ethernet or fiber-optic cables are laid. This cable length is frequently insufficient.

“When the devolo Giga Bridge is used for the cabling between the NT/ONT and router, it yields enormous cost and time savings for both providers and customers.”

4.1 Time and cost savings

Once the fiber-optic connection has been successfully connected to the subscriber delivery point, the next step is to find the optimal place for the active NT/ONT and router. Often the NT/ONT is placed right next to the subscriber

delivery point, so the two devices can be easily connected to each other. It is significantly more difficult to make the following connection between the NT/ONT and router, because many customers know that the correct router placement plays an important role.

4.1.1 Optimising an installation service

For the provider, the additional flat rate for an installation service is just a friendly additional option for customers so that they can start using the ordered fiber-optic connection right away. The low flat rate is not meant to achieve high monetary gains, seeing as the cable laying, which may even include putting holes in walls or ceilings, is time-consuming. If you also take into consideration here the material costs for the installation of two outlets (LAN or fiber-optic) and the travel cost of the technician, the flat rate quickly becomes a losing bargain. After all, the time that a technician spends at a customer location for an installation cannot be used for other customers.

The devolo Giga Bridge provides a remedy for this, since the connection between the NT/ONT and router is taken care of without much effort, entirely without time-consuming handiwork. This allows existing, unused telephone outlets to continue to be used without renovation. The same holds true for a conventional telephone connection cable. Even easier is connection of the devolo Giga Bridge using existing TV cabling, since in this case the SAT and TV connection cables can be used. For common distances, which are about 30 to 40 metres in a single-family home, the plug connectors have no significant influence on the speed of the Giga Bridge. Thus, providers can carry out installations more quickly and cost-effectively while covering more customers.

4.1.2 Comparison of installation effort without/with Giga Bridge

Table 1/4

Installation effort	New cabling	With Giga Bridge
Phone support	Complicated: Asking about installation requirements, details about cable laying options. Agreement on the options for installation work (drilling: noise and dirt).	Simple: Clarification of whether phone or SAT/ TV cabling is present and where.
Co-ordination with the landlord	Required in case of tenancy	Not required
Preliminary planning and inspection of the construction site	May be required (for complicated cable routing)	Not required
Appointment scheduling for construction measures	Required	Can be coordinated during the consultation (step 1)
Laying cables	Lay a new Cat 6/7 cable	Not required
Connecting a termination outlet to the NT/ONT	Set/terminate RJ45 jack	Remove telephone cable from TAE outlet / set/ terminate RJ45 jack

4.1.2 Comparison of installation effort without/with Giga Bridge

Table 2/4

Installation effort	New cabling	With Giga Bridge
Connecting a termination outlet to the router	Set/terminate RJ45 jack	Not required
Measurement of the connection	Measurement of the data link including RF properties and measurement log, requires a network multimeter	Easy measurement with cable tester (wire pairs 4/5, optionally 4/5 and 3/6)
Pairing of devices	Not required	Plug both Giga Bridge adapters into a power socket and use network patch cord to connect to the G.hn port (phone). The pairing happens automatically.
Start up the Giga Bridge at the NT/ONT	Not required	Plug one of the Giga Bridge adapters on the NT/ONT into the power socket and plug the mains adapter of the ONT into the integrated electrical socket of the Giga Bridge adapter. Then connect the phone port and RJ45 outlet (new) using network patch cords.

4.1.2 Comparison of installation effort without/with Giga Bridge

Table 3/4

Installation effort	New cabling	With Giga Bridge
Starting up the Giga Bridge at the router	Not required	Plug the second Giga Bridge adapter on the router into the power socket and plug the mains adapter of the router into the integrated electrical socket of the Giga Bridge adapter. Then connect the phone port and RJ45 outlet (new) using network patch cord.
Logging the measurement	Create a protocol of the network measurement	Connect the ETH port of the Giga Bridge on the router or on the NT/ONT to the network port of the PC and start the devolo Service Tool. Use the Service Tool to create a protocol.
Network connection to the NT/ONT	Connect the RJ45 port of the connection socket to the ETH port of the NT/ONT using a network cable	Connect the RJ45 port of the Giga Bridge to the ETH port of the NT/ONT using a network patch cord.

4.1.2 Comparison of installation effort without/with Giga Bridge

Table 4/4

Installation effort	New cabling	With Giga Bridge
Network connection to the router	Connect the RJ45 port of the network outlet to the WAN port of the router using a network patch cord.	Connect the RJ45 port of the Giga Bridge to the WAN port of the router using a network patch cord.
Testing the network or Internet connection	Required	Required
Creating an invoice	Required	Required

4.1.3 Time savings in the installation effort

Installation effort	Conventional installation (new cabling)		With devolo Giga Bridge	
	Min. time	Max. time	Min. time	Max. time
From the preliminary information-gathering process over the phone to the installation, connection and log measurements and even invoice creation	100	180	15	40
Time savings in minutes / overall			85	140
Time saving			85 %	78 %
Max. number of installations per day/technician	5	3	32	12
Increased efficiency of installations per day/technician			640 %	400 %

As the table shows, the devolo Giga Bridge saves up to 85 percent of the installation time is saved. This time savings runs through the entire process, in other words, from the consultation of a future customer and preliminary information-gathering process over the pho-

ne to the installation, log measurements and final set-up. The enormous potential for time savings is a big advantage for customers as well as providers. On the one hand, customers have greater flexibility during the set-up (no dirt, no noise) and get to enjoy their new con-

nection more quickly. On the other hand, the number of sales that providers can close is significantly more than with conventional new cabling due to the substantially lower installation effort of the devolo Giga Bridge. Based on the calculated time savings and the grade of installations per technician resulting from this, there is a significant increase of up to 640 percent. Thus, providers are not only able to carry out up to six times as many installations per technician per day, but can also save money with the devolo Giga Bridge.

4.2 Maximising sales, reducing service costs, minimising customer dissatisfaction

Most customers interested in a faster fiber-optic connection often end up changing their mind. One of the reasons for that is the previously mentioned installation of a connection between the NT/ONT and router. Customers may not want to pay for an installation service because they think the costs are too high or the range of the cable laying is insufficient for their purposes. In addition, particularly in case of tenancy, having cables laid is not even always an option because a structural change to the leased property requires the express permission of the landlord.

In these cases, customers are left with no choice but to take independent action. Depending on how customers carry out the cabling from the NT/ONT to the distantly located router, they may find that the fiber-optic connection's gigabit speed is not available at the access point for terminal devices (routers). Selection of the wrong cable or placing the (Wi-Fi) router in a basement or garage will cause a rapid drop in the transmission rate of the fiber-optic connection – and a drop in the

customer's satisfaction level. For providers, in turn, the support costs rise sharply. After all, each contact with a customer costs money. Ultimately, to solve the speed problems addressed above, the installation service of the provider will have to be used.

Using the devolo Giga Bridge cuts down on costs because the transmission rate from device to device is up to 1 Gbps – in other words, full fiber-optic speed. This virtually eliminates the need for making contact with customers to address speed issues. This is good news for customers as well, since the devolo Giga Bridge can be installed by either the provider or the customer. The wait time for an installation appointment, which in the past could very well be several weeks, is significantly shortened thanks to efficient installations. The same is true for the set-up, which is completed within a few minutes. In addition, the costs turn out to be lower than they are for the hassle of laying new cables. No more burdensome preliminary work is needed to enjoy the benefits of a fiber-optic connection in a home network.

“Thus, providers are not only able to carry out up to six times as many installations per technician per day, but can also save money with the devolo Giga Bridge.”

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