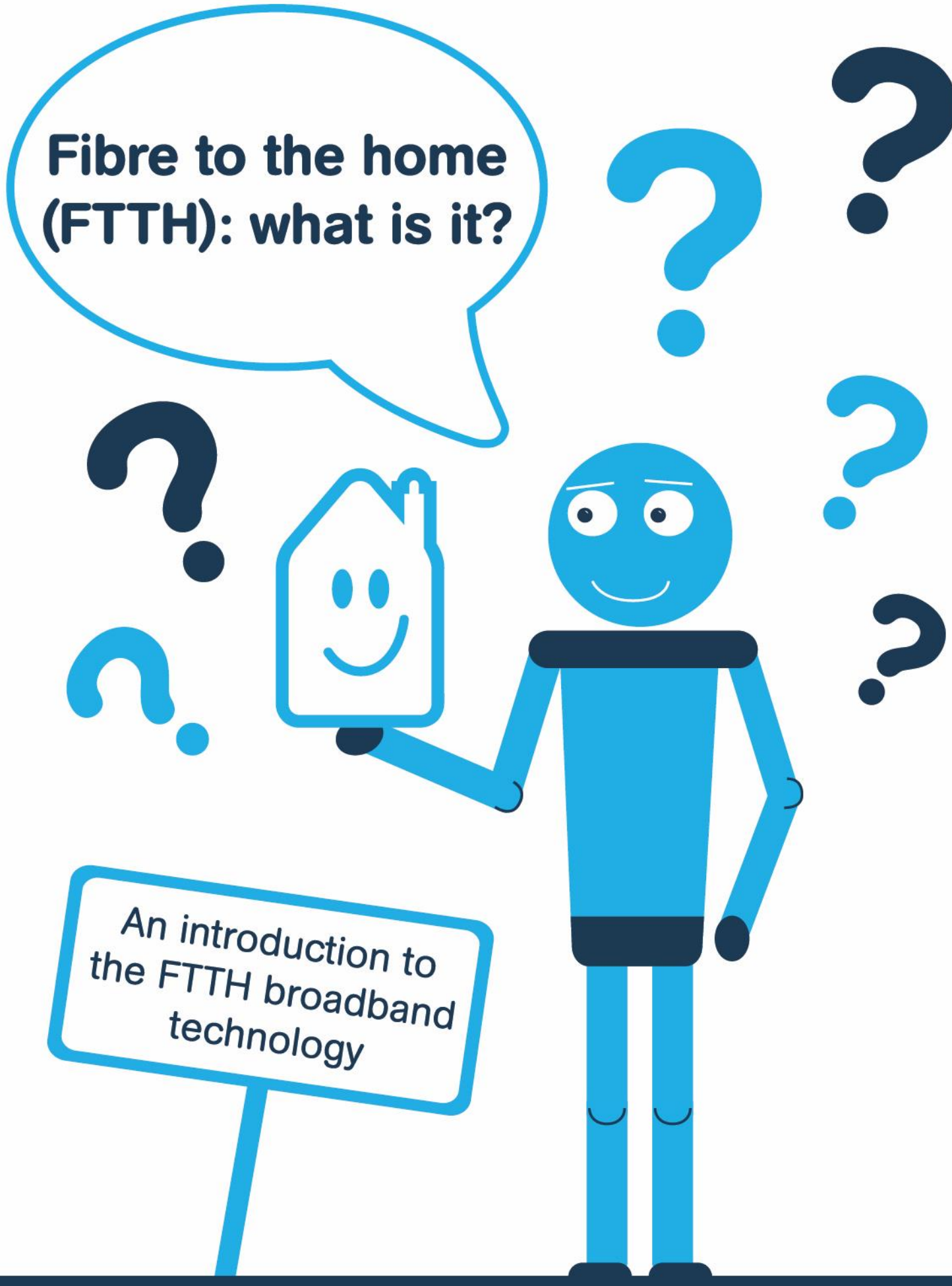
Fibre to the home (FTTH): what is it?



A White Paper by the Deployment & Operations Committee

Fibre to the Home Council Europe

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About the FTTH Council Europe

The FTTH Council Europe is an industry organisation with a mission to accelerate the availability of fibre-based, ultra-high-speed access networks to consumers and businesses. The Council promotes this technology because it will deliver a flow of new services that enhance the quality of life, contribute to a better environment and increase economic competitiveness. The Council consists of more than 150 member companies. www.ftthcouncil.eu

Longing for a better Internet connection? Join "I want Fibre" page on Facebook:

www.facebook.com/pages/I-want-fibre/174248502650699

Foreword

Accelerating the availability of fibre-based, ultra-high-speed access networks to consumers and businesses is not that easy when you realise that the FTTH technology and the way it works are not that familiar to the general public.

This guide, edited by our organisation, aims to define the basics of the fibre to the home (FTTH) broadband technology. We will thus lead you throughout this guide to the most accurate definition of FTTH. What is optical fibre? How does it work? What are the factors that push to the generalisation of fibre to the home adoption? From the components to the network infrastructure, we'll go into details of the fundamental elements that constitute an FTTH network, allowing the optical fibre to reach the end-user home.

The particularity of this guide lies in its general scope: it is intended to cover numerous FTTH issues and questions raised by a non-specialised audience. We would like with this guide to enlighten the concerned but novice citizen whose life is impacted by telecommunications yet feels a bit lost in this environment. In other words, if you are not familiar with the FTTH technology and you want to learn what it is, this guide is made for you!

Furthermore, our goal is to educate various publics that could contribute to accelerate FTTH adoption and rollout throughout Europe, among them politicians, stakeholders, decision makers and of course consumers. This public needs to be aware of the benefits brought by this technology from a technical point of view. FTTH is a future-proof technology whose voice needs to reach as many people as possible within our society.

Introduction

Telecom services are everywhere in your daily life!

Confused about telecom technologies and acronyms?

Fibre to the home… where should we start? You may have heard lots of references to broadband networks! ADSL, VDSL, xDSL, copper, cable, fibre broadband, high speed, bandwidth, FTTC, FTTB, FTTH, next generation access… The list goes on and on. But what does it mean?

Feeling confused about these technologies and all those acronyms? No need to worry; first you are not alone, second, it's really quite simple! Let's forget all these seemingly obscure names, and instead focus on YOU! To start this guide and understand FTTH, the fundamental question is the following: what do you care about as a customer?

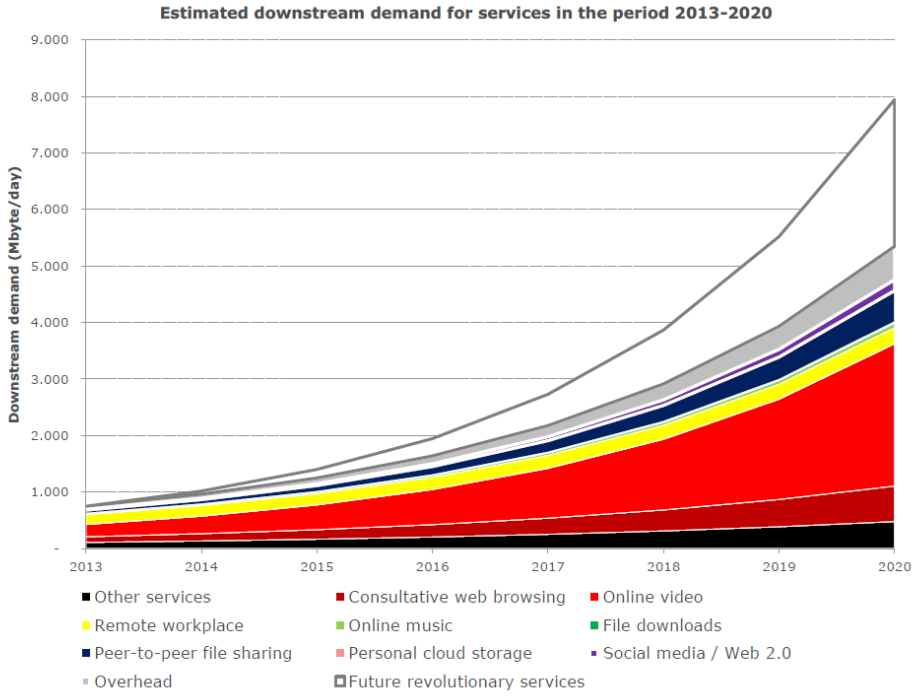
New needs for society: what do you care about?

Our current consumption habits show how quickly digitization has encapsulated everything, turning business models, the economy and our lives upside down. Such new needs have had major repercussions on the telecommunications industries, and they need to be understood before we can look at the solution the industry has offered. In other words, what do YOU care about as a customer?

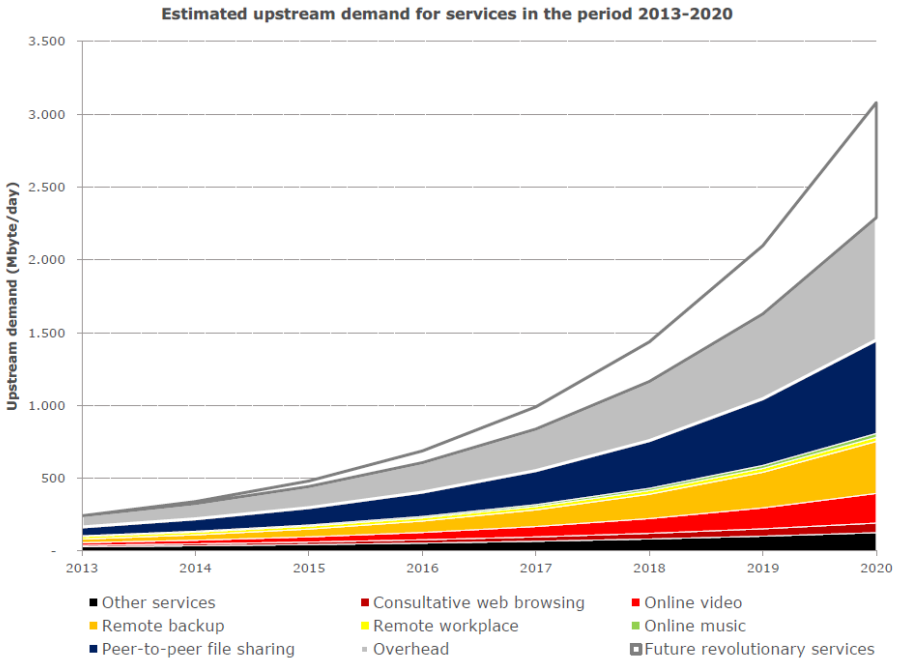
- Getting fast Internet access to send and receive music, pictures or videos in an instant
- Making affordable phone and video calls with family and friends, wherever they are
- Working from home as easily as in the office
- Watching HD TV programmes
- Watching Videos on Demand
- Playing online games with friends
- Making an instant online backup of data and sharing it with family and friends

How do telecom services make the demand for bandwidth grow exponentially?[1]

Browsing the web, listening to online music, downloading files, watching videos on demand etc. causes exponentially growing **downstream** demands (getting data from the Internet to your home/devices). The global downstream demand for 2020 is estimated at almost 8,000 Mbyte per day:

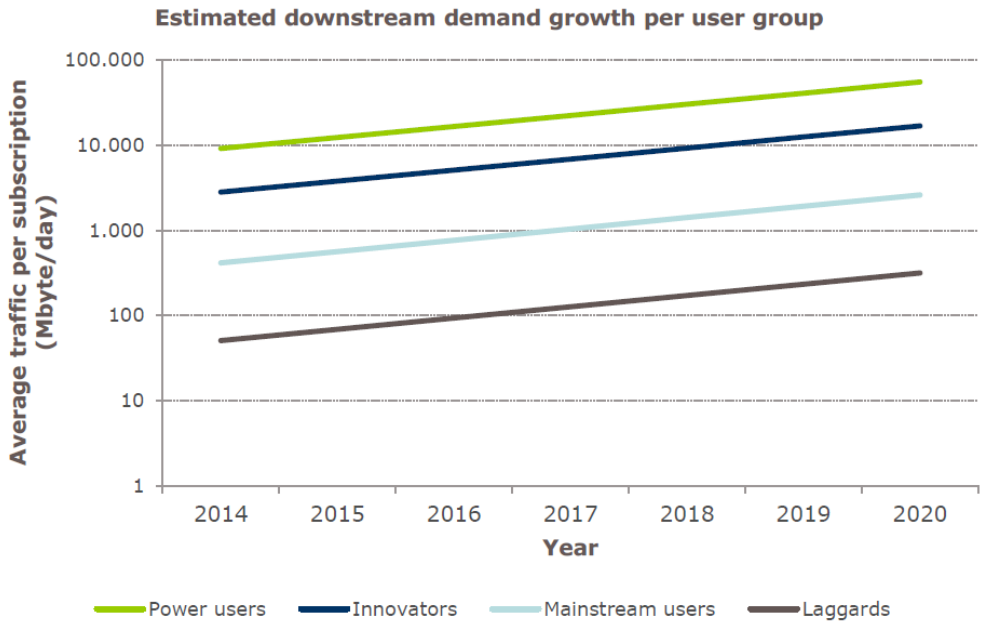


Working from home, storing documents, photos and videos in the cloud, but also web browsing, causes exponentially growing **upstream** (moving data from your home/devices) to the Internet. The estimated demand for daily upstream traffic in 2020 will be over 3,000 Mbyte per day:



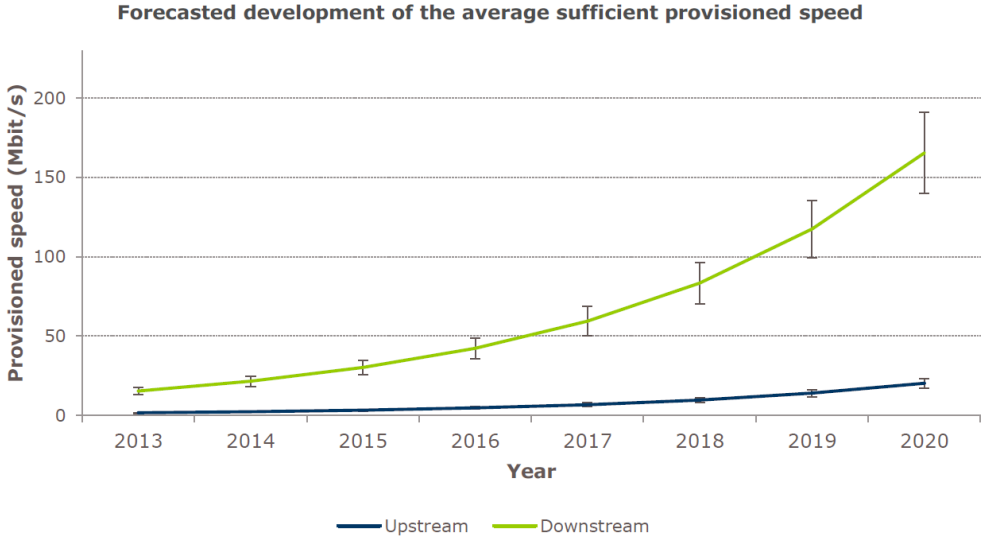
[1] *Chapter sources: Chapter 2, Fast Forward, TU/e Eindhoven, Dialogic, 2014:*
http://nlkabel.nl/wp-content/uploads/2014/06/onderzoek-Dialogic-Fast-Forward-2014.pdf

Furthermore, both downstream and upstream demand is expected to grow **exponentially** over the next seven years for all user groups: “power users”, “innovators”, “mainstream users” and even the “laggards”:



The need for speed greatly depends on the user group:
In 2020 the “power users” have an estimated demand of 1,155 Mbit/s downstream and 315 Mbit/s upstream, for the average user speeds are forecast to be 165 Mbit/s (downstream) and 20 Mbit/s (upstream) and laggards have an estimated downstream demand of 6.6 Mbit/s and an upstream demand of only 0.8 Mbit/s.

This exponential growth of the downstream and upstream information flow in turn causes a continuous growing need for a higher speed (increased bandwidth) of the connection between you and the Internet:



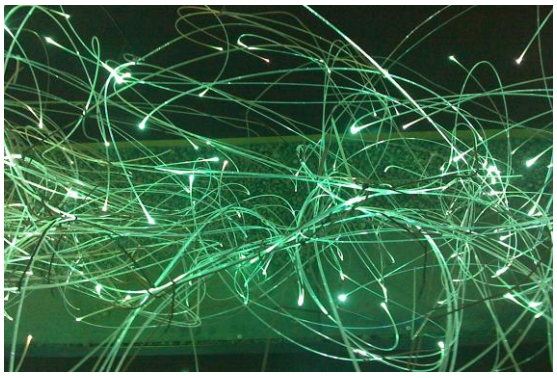
How can telecommunications operators cater to these new needs?

Broadband connectivity has made considerable progress in the last decade. However, because consumers have **higher expectations** of telecoms providers, there is still room for improvement, and this will continue until everyone connects to a satisfactory broadband infrastructure. While more and more of us manage our daily activities online, the new and increasing needs highlighted in the chapter above require operators to **provide instant and reliable services** in various areas such as entertainment, e-health, security, etc. Telecoms companies need to invest much more heavily towards improving their networks and making them capable of carrying large amounts of data to meet those new consumer expectations. For example, as video, audio, and other services such as Netflix and Spotify gain importance in popularity and usage, the operators' task to meet this growing demand becomes that much more difficult: they must prove that they can offer high-quality, state-of-the-art, and reliable broadband services.

Of course, telecommunications operators cannot achieve these objectives on their own. Several local and national protagonists have to play their part so that broadband technology is able to respond to exploding data traffic and new demands for more capabilities, service offerings and better customer experience. The Digital Agenda[2] presented by the European Commission calls on its Member States to better exploit the potential of Information and Communication Technologies (ICT) in order to foster innovation, economic growth and progress. The main objective is to develop a Digital Single Market (DSM) by 2020 in order to generate smart, sustainable and inclusive growth in Europe. As such, many High Speed initiatives have been developed by several European governments, among them France, Sweden and Lithuania for instance.

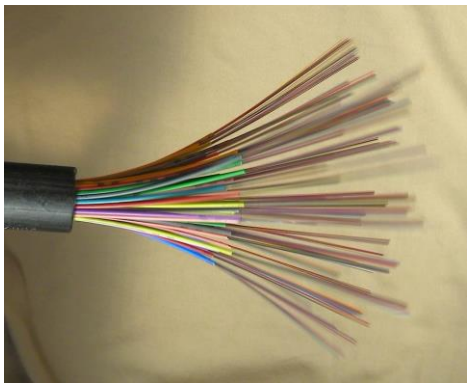
It is within this vision of growth and renewal, and the challenge of having the right communications infrastructure in place to meet this ever-growing need for speed, that fibre to the home plays an essential role as the solution for the future. If you are not that familiar with this broadband technology, don't worry. Just relax and read on!

What is optical fibre?



If you think optical fibre has any link with the picture on the right, this brochure will definitely be of some help for you! If you chose the left one, you might be a step ahead, but do not rest on your laurels, this is just the beginning! Yes, it has to do with how we use our electronic devices, but what is optical fibre really?

[2] http://ec.europa.eu/digital-agenda/en



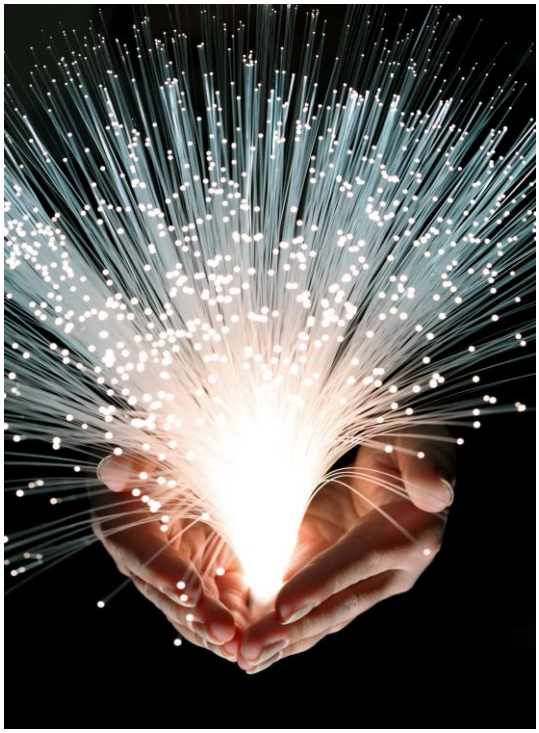
Optical fibres are **flexible hair-thin strands of glass that transmit light**, and by extension data. This data is transmitted digitally, rather than analogically, across distances of hundreds of kilometres. Because the optical fibre is extremely fragile, it is normally covered with a high-strength, lightweight protective material. Optical fibre lines present several advantages over traditional metal communication lines. Not only fibre optic cables are much thinner and lighter than metal wires, but they are also less susceptible to electronic interference.

*DID YOU KNOW? We cannot address optical fibre without doing a little bit of history. Let's take a minute to honour the man affectionately called the **"Father of Fibre Optics" Sir Charles K. Kao**. He was first to demonstrate that it was indeed possible to prepare optical fibres in such a way as to allow light to travel through them across vast distances. His work laid the foundation for all modern fibre-optic communication networks. Kao received the Nobel Prize in Physics in 2009 for "ground-breaking achievement concerning transmission of lights in fibre for optical communication".*

How do optical fibres work?

Now that you know what an optical fibre means, we should focus on the specific details of how the technology works.

Basically, **data travels through a fibre optic cable as a pulse of light propagated along the cable via reflection**. At this point, you are probably thinking: Fine, but HOW does it work?



To answer this question, let's give a real life example[3]. For instance, imagine you and your friend are taking a walk and you come to a long –very long- and winding tunnel. You walk through the tunnel while your friend who happens to be afraid of the dark stays back. Now imagine that you want to see your friend by shining your flashlight through the tunnel. The problem is that you can only see as far as the first bend in the tunnel since light travels in a straight line and the tunnel is curved. What would the solution be? Well, you would need to set up a series of angled mirrors at each bend so that the light can bounce on the reflective surfaces and finally reach your friend. Well this is essentially how optical fibre works!

[3] Example inspired from Cable.co.uk : Guide *How does fibre optic broadband work?* *https://www.cable.co.uk/guides/how-does-fibre-optic-broadband-work/*

In this example, the light shining from the flashlight is similar to the data transmitted as light through optical fibre cables. The light signals are transmitted from one end, and each tiny photon (particle of light) **bounced successively off a series of mirrors** through the cable to reach the opposite end. The glass itself acts as a mirror. In order for optical fibres to transmit data over long distances, the fibres must therefore be **highly reflective**.

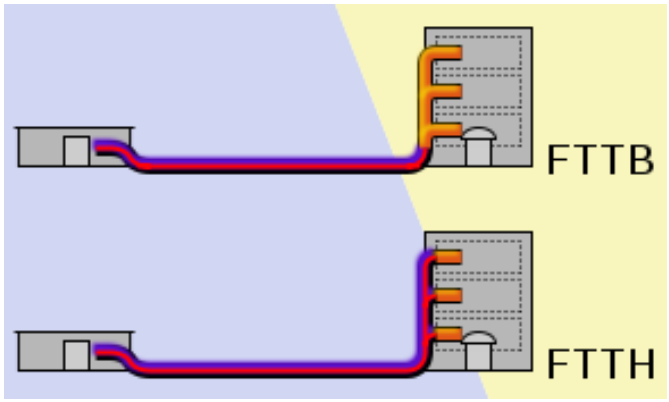
Why fibre "TO THE HOME"?

Now that you are aware of everything you need to know about optical fibre as a telecommunications medium, let's look at how it is used in the fibre to the home broadband technology. More precisely, let's see what "to the home" means in this specific communication infrastructure. First, back to you, the user of Internet services via devices in your home premises. As you know, you must subscribe to Internet broadband via a telecoms operator. This allows you to upload and download data via a broadband connection. The network (remember the tunnel example) may use optical fibre in some parts of the network, but not in others. This is where fibre to the home comes in. The FTTH Council Europe defines "fibre to the home" as[4]:

An access network architecture in which the final connection to the subscriber's premises is optical fibre. The fibre optic communications path terminates **on** or **inside the premises** for the purpose of carrying communication services to a single subscriber.

In order to be classified as FTTH, the fibre access must reach the boundary of the subscriber's premises and terminate:

- inside the premises, or
- on an external wall of the subscriber's premises, or
- no more than 2m from an external wall of the subscriber's premises.



Source: *FTTH Handbook*, D&O Committee, FTTH Council Europe, 2014

We only promote Fibre to the Home (FTTH) and Fibre to the Building (FTTB)*, because we believe that only these solutions offer the bandwidth and symmetry necessary to allow the development of services and applications that make a difference to the way we live and work.

[4] www.ftthcouncil.eu/documents/Publications/FTTH_Definition_of_Terms-Revision_2015-Final.pdf

Comparison with other broadband solutions: speed, reliability and security[5]

FTTH has obvious advantages for the consumer, both today and in the foreseeable future, offering improved performance for broadband services in comparison with those currently delivered primarily over copper networks.

Speed

The speed comparison factor might be the most convincing one for you as customers. FTTH provides the highest possible speeds of Internet access **downstream** (from the network to the end user) as well as **upstream** (from the user to the network). Mobile connections are much slower than FTTH, especially when several users are in the same area and share the available network. Satellite connections are also much slower than FTTH: they entail a delay, which hampers phone conversations and other interactive activities. Other fixed technologies, like ADSL, use metal wires - which are about **100 times slower than fibre to the home** – to connect your home to the fibre city network.

Keeping in mind that FTTH allows at least 1 Gbps download and 1 Gbps upload, the following table drawn by the FTTH Council Europe shows typical download and upload speeds for photo and video transfer for different bandwidth combination:

Time taken for:	1 GB photo album	4.7 GB standard video	25 GB HD video
1 Gbps download 1 Gbps upload	9 sec	39 sec	3 min 28 sec
100 Mbps download 100 Mbps upload	1 min 23 sec	6 min 31 sec	34 min 40 sec
50 Mbps download	2 min 46 sec	13 min 2 sec	1 hr 9 min
10 Mbps upload	13 min 52 sec	1 hr 5 min	5 hr 47 min
8 Mbps download	19 min 0 sec	1 hr 29 min	7 hr 55 min
1 Mbps upload	2 hr 32 min	11 hr 54 min	-

An interactive Fibre Speed comparison tool is available on the FTTH Council Europe website: www.ftthcouncil.eu/about-us/about-ftth/fibre-speed-tool

Reliability

Even though FTTH speed is remarkable, we should consider other factors that also impact on the end-user service. Reliability is definitely one of these factors. An FTTH broadband connection offers an **improved network reliability**. Why?

[5] Chapter source: www.ftthcouncil.eu/documents/Publications/FTTH_Business_Guide_2013_V4.0.pdf

Let's do a bit of science now! Do you know about electromagnetic interference (EMI)? Electromagnetic interference is a common type of noise that originates with one of the basic properties of electromagnetism. Magnetic field lines generate an electrical current as they cut across conductors. Fibre optics transmissions are **immune** to this EMI since signals are transmitted as light instead of current, allowing them to carry signals through places where EMI would block transmission. While optical fibre is immune to electromagnetic interference, the transmission performance of other technologies like DSL is subject to random noise, as well as other interferences and crosstalk during operation which impact the overall throughput. Furthermore, optical components are **extremely reliable** in other ways as well (resistant to high temperature, humidity and fire and effective in specific environment such as undersea).

Security

The reliability factor is linked with security. To follow on the example above, magnetic fields and current induction work in two ways. They don't just generate noise in signal carrying conductors; they also make it possible to leak out the information that is on the conductor. There are no radiated magnetic fields around optical fibres; the electromagnetic fields are confined within the fibre. That makes it impossible to tap the signal being transmitted through a fibre without cutting into the fibre. Secure fibre networks can therefore **help protect content from piracy** when other broadband solutions are more likely subject to these kinds of virtual threats or even viruses. As you can imagine, security and reliability are crucial to the data distribution in areas such as health services.

The ultra-high speed trouble-free and future-proof FTTH technology

It is a fact that has been repeatedly demonstrated that out of all the broadband technologies and solutions, FTTH is the **fastest and most reliable way to access the Internet.** Just imagine, with fibre to the home, you can download the film in minutes, even if your kids are also on a video call with their grandmother! And the superiority of the FTTH technology is not going to end soon. FTTH is **future proof** and its capacity to send and receive increasingly more data faster is virtually **unlimited**.

What makes FTTH special is that it removes the network bottlenecks:

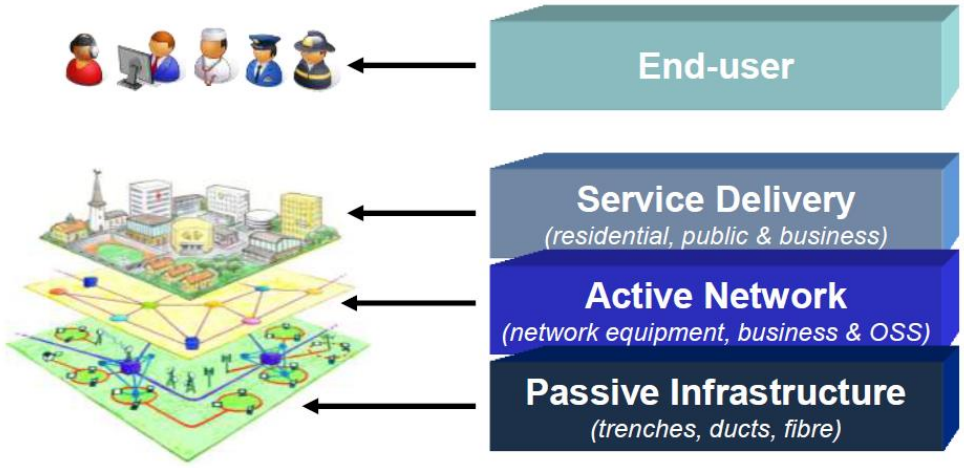
- Download speeds are very fast, so the network never holds you back.
- Upload speeds – often painfully slow using older technologies like ADSL – are dramatically improved. This allows data files such as family photos to be uploaded (sent) quickly and makes it possible to use interactive services, like video communication, with ease.
- Aside from bandwidth, parameters like latency (the delay of data being sent through a network) are important, in particular with regard to real time services; and latency is at its lowest with FTTH compared to other technologies.

FTTH is not just about Internet access. FTTH opens the door to a **wide range of new services and applications**, both for entertainment and productivity, delivered right to the home or the office. These include video communication with friends/family and colleagues, video-on-demand, online gaming, teleworking, eHealth services and much more.

Appendix 1: The FTTH layered network

An FTTH network comprises of a number of different layers:

- the *end users*, such as you
- the *retail services* providing Internet connectivity and managed services; in other words, the applications and services that you use
- the *active network* using electrical equipment and managed by service providers (e.g. telecoms operators)
- the *passive infrastructure* involving ducts, fibres, enclosures and other outside plants



Source: *FTTH Handbook*, D&O Committee, FTTH Council Europe, 2014

Basically, the FTTH network consists of a **passive fibre infrastructure** and **active equipment** to enable distribution of the communication services to the service providers and end-users.

Active network

It might seem evident at this level, but it is still important to mention: to be connected to the Internet, there needs to be a laser! The laser sends pulses of light through the fibre optic cable. The pulses are turned off and on very quickly and translate into digital information. Multiple streams of information are carried at the same time by using multiple wavelengths – colours – of light.

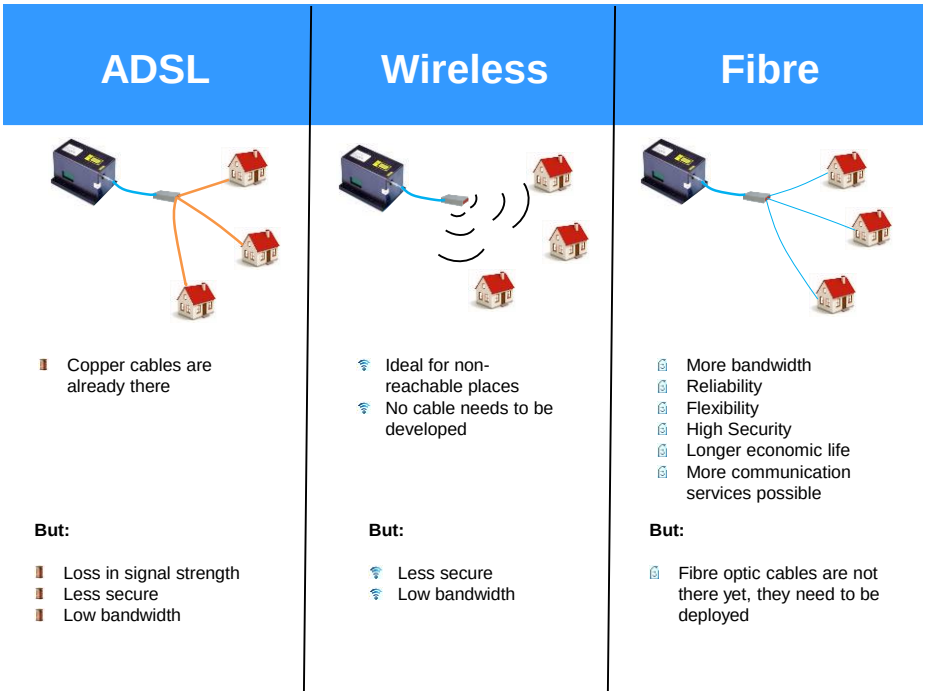
Today, an Internet connection can be made via one of the following technologies:

Copper cable

Wireless 

Most important, fibre optic cable

Fibre offers many advantages when looking at the **active network**, as shown on the next image.

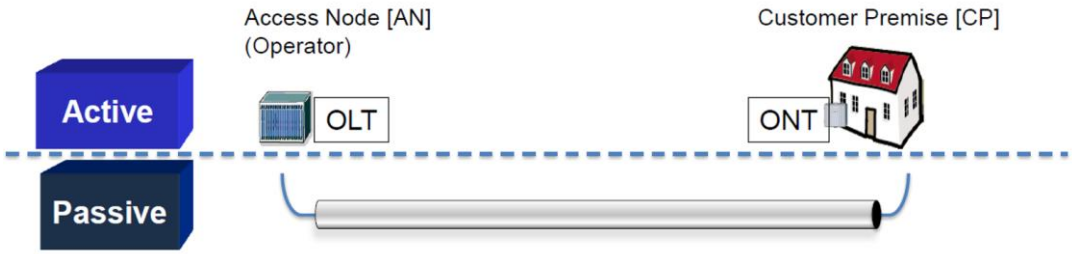


Source: *FTTH for beginners* Presentation, FTTH council Europe, 2013

We have explained how fibre optic cable carries information by transmitting pulses of light. We have also argued that from a technical point of view, what is unique about optical fibre is that it can carry high bandwidth signals over enormous distances. Being as thin as a human hair, fibre optic strands can be hidden easily behind the surfaces of walls in most dwellings. Furthermore, the equipment necessary to send light signals keeps improving. Equipping an existing fibre network with newer electronics and lasers that pulsates light faster, or lasers using different wavelength of light, can vastly increase available bandwidth without changing the fibre itself. Once fibre has been deployed, network operators can keep increasing bandwidth at very little costs. As we said earlier, FTTH is **future proof**!

Passive infrastructure

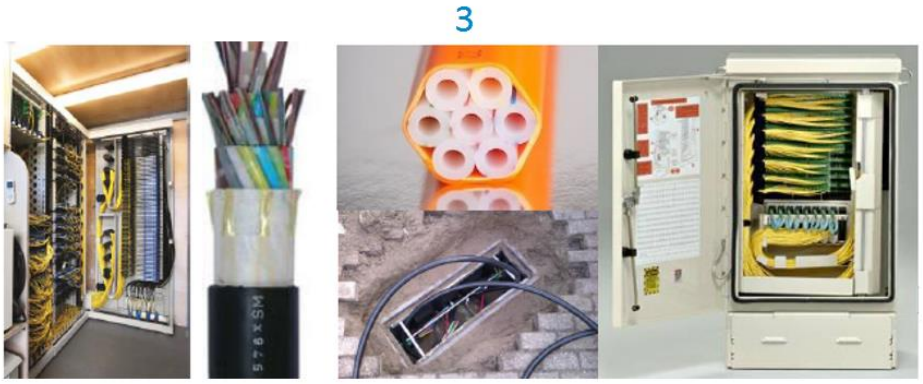
Let's move on now to the passive infrastructure. As pictures often speak louder than words, take a look at this detailed illustration:



Source: *FTTH Handbook*, D&O Committee, FTTH Council Europe, 2014

To fully understand this illustration, you will find some technical definitions in our Appendix 2 (p.15).

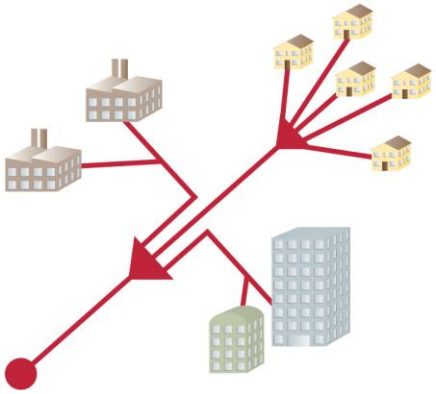
Seen from the active layer, the passive layer seems simple as represented above as a simple pipe. This end-to-end pipe, from Operator's AN to customer's premise transports light to and from Optical Line Termination (OLT) and Optical Network Termination (ONT). However, the passive infrastructure is far from simple when you look at what's inside the pipe. It really consists of many different components including:

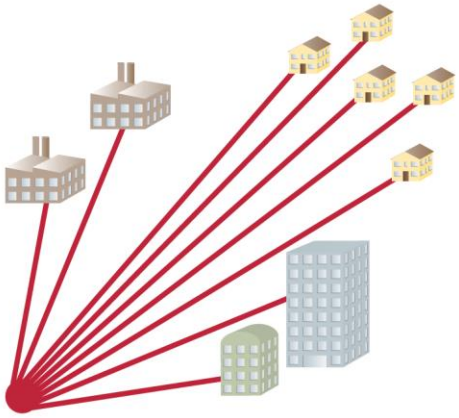


1) Optical distribution Rack/Frame *
2) Fibre/Cable
3) Microduct Bundle*
4) Manhole*
5) Cabinets*

As you may imagine, an FTTH infrastructure can be built differently according to many factors, such as capacity and speed. The structure in itself is the result of these factors. Here are the two FTTH topologies for the passive infrastructure[6]:

Point-to-Multipoint (P2MP): in this topology, one fibre leaving the AN will feed a splitter with multiple outgoing fibres. This means the capacity of this feeding fibre is shared between these outgoing fibres. Since capacity is shared, the higher the end-to-end split ratio, the lower the maximum bandwidth per customer will be.





Point-to-Point (P2P): in this topology, a dedicated fibre is available from the AN to a specific customer premise. No bandwidth capacity is shared, but high fibre counts must enter the AN (one per customer), requiring large amounts of active equipment in the AN.

[6] *FTTH Handbook*, D&O Committee, FTTH Council Europe, 2014

Appendix 2: Glossary and acronyms

Access node AN*:* starting point for the optical path to the subscriber. It houses all active equipment from the operator. This is often also referred to as Central Office [CO] or Point of Presence [POP]

Active network: the layer of the FTTH network that uses electrical and network equipment, such as copper or fibre optic cable

Cabinet: cabinets are installed at flexibility points in order to allow easy access to the fibres, cables and ducts, while offering protection against environment (weather, vandalism…)

Fibre to the building (FTTB): an access network architecture in which the final connection to the subscriber's premises is a physical medium other than optical fibre. The fibre optic communications path is terminated within the building for the purpose of carrying communication services for a single building with potentially multiple subscribers.

Fibre to the home (FTTH): an access network architecture in which the final connection to the subscriber's premises is optical fibre. The fibre optic communications path is terminated on or inside the premises for the purpose of carrying communication services to a single subscriber.

Homes Passed: the potential number of premises to which a service provider has capability to connect in a service area. Typically, new service activation will require the installation and/or connection of a drop cable from the homes passed point (e.g. fiber-pedestal, manhole, chamber, and utility-pole) to the premises, and the installation of subscriber premises equipment at the premises. This definition excludes premises that cannot be connected without further installation of substantial cable plant such as feeder and distribution cables (fiber) to reach the area in which a potential new subscriber is located.

Manhole: manholes are typically concrete chambers that are covered by a metal lid, and are intermediate locations in the network that allow access to ducts and/or cables.

Microduct: Microducts are small ducts, typically between 7 and 20mm in diameter, intended for the installation of fibre-optic cables. They can be used either as single pipes or grouped as bundles in either a round or flat configuration with a sheath to hold the bundle together

Optical fibre: flexible hair-thin strands of glass which transmit light, and by extension data

Optical distribution frame: a frame enabling the fibres from the outdoor cables to become available on an individual fibre level for flexible patching with the active transmission equipment.

Optical Line Termination: the active equipment at the operator side that sends and reads optical signals.

Optical Network Termination: the active equipment at the customer side that sends and reads optical signals.

Passive infrastructure: the layer of the FTTH infrastructure that lies on trenches, ducts and fibre. It is represented by a pipe from Operator's Access Node to Customer's premise that transports light between Optical Line Termination & Optical Network Termination

Point-to-Multipoint (P2MP): when one fibre leaves the AN to feed a splitter with multiple outgoing fibres. This means the capacity of this feeding fibre is shared between these outgoing fibres. Since capacity is shared, the higher the end-to-end split ratio, the lower the maximum bandwidth per customer will be.

Point-to-Point (P2P): when a dedicated fibre is available from AN into each customer premise. No capacity is shared, but high fibre counts are entering the AN, requiring also large amounts of active equipment in the AN.

Premise: a home or place of business.

Subscriber: a premise that is connected to a network and uses at least one service on this connection under a commercial contract.

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