FTTH-THEORY

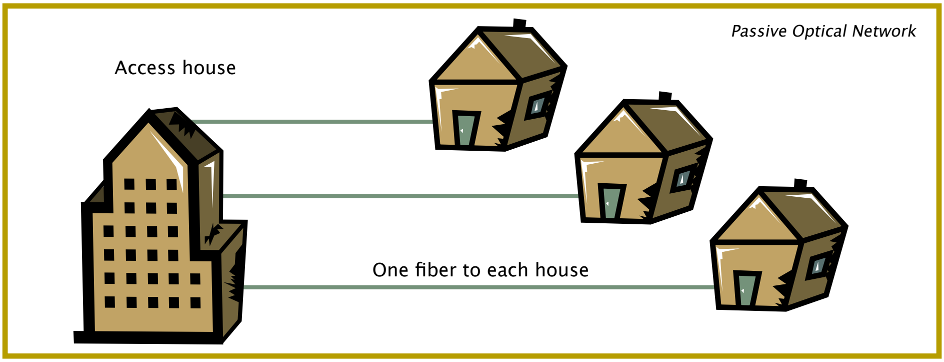
FTTH Theory

To put it simply, FTTH (Fiber To The Home) is about getting fiber out to each individual household. Two basic variants exist, PON (Passive Optical Network) and AON (Active Optical Network).

PON

A Passive Optical Network begins with one single fiber, that is distributed to 16, 32 or 64 customers. It is called a passive network, as the actual splitting up is done by a device called a passive splitter(one which needs no power).

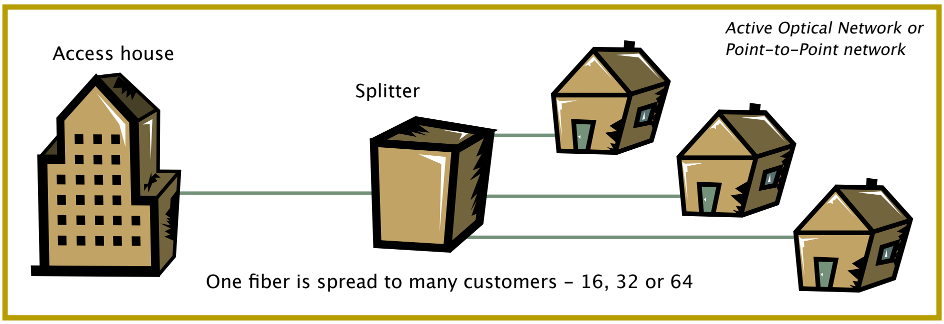
Figure 1



AON/P2P

With regard to an Active Optical Network, there is a fiber connection to every customer. For example, if you have 32 customers, you will have to lay out 32 fiber connections. An AON is also called a P2P network (Point-to-Point network).

Figure 2



Regarding the PON access house, the biggest advantage is the somewhat smaller amount of fiber and electronics – compared to an AON access house. Fiber and electronics take up less space, and the power consumption is lower. An additional advantage is, that the installations are easier to manage.

On the other hand, customers will have to share the bandwidth. Special media converters must be placed close to the houses, separating the customers from one another. The biggest problems, however, concern measuring and trouble-shooting. Measuring and trouble-shooting is troublesome, and you will need an Optical Time-Domain Reflectometer (OTDR), an instrument that requires skill as well as experience to use.

Quite many PON standards exist, and new ones turn up all the time to compensate for the ongoing bandwidth development.

APON (ATM PON)

This was the original PON standard, based on ATM cells, small packets which were usable for everything from telephony to video. There was not much bandwidth available for the customers.

Figure 3

A splitter – PON installations are build with splitters. This is an example of a splitter with two ports.

BPON (Broadband PON)

This standard was designated as Broadband PON, a solution with more available bandwidth. But the customers were still in the slow lane of the internet highway. The standard was not widespread.

EPON (Ethernet PON)

The first two PON standards had the disadvantage that, close to the customer, the data had to be converted from ATM cells to Ethernet, which is commonly used. As a consequence of this, much data power was needed and furthermore it was time consuming. That is why EPON was developed. But still, the amount of bandwidth was not sufficient.

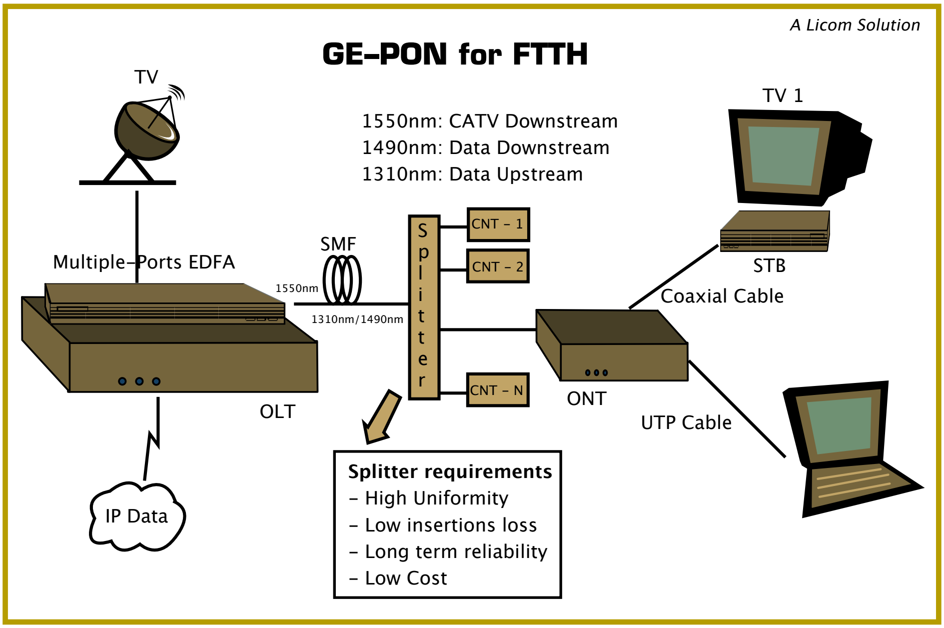
GPON (Gigabit PON)

The latest addition is Gigabit PON, which is now used as the standard PON solution. As for security, the problems have now been solved. All users of PON systems get all packages, and that is why safety was a problem. GPON uses ATM cells too, and therefore a conversion to Ethernet is necessary.

GEPON (Gigabit Ethernet PON)

Solutions, using ethernet frames have now turned up, making the electronics cheaper, as the technology is well known and widespread. Even though not that many choose this solution, it absolutely has its benefits.

Figure 4



10GPON (10 Gigabit PON)

This solution will bring more bandwidth to everybody, but still not unlimited. Then again, you will have to consider both the needs of tomorrow and the original investment. 10GPON solutions in practice is yet to be seen.

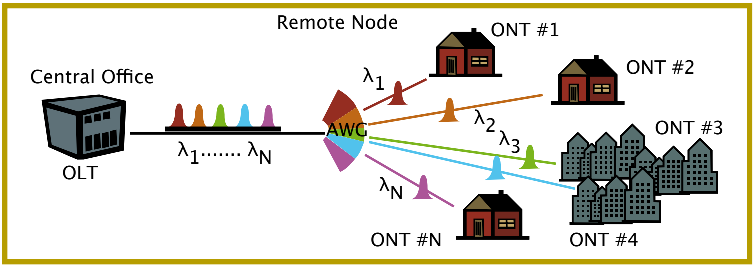
WDM-PON (Wavlength Division Multiplexing PON)

All the previous solutions are based on the use of one fiber only and the splitting of the signal to a number of users. If it is a 1:32 system, every user will get only one-thirty- second part of the bandwidth and one-thirty-second part of the power. The power is only of importance with regard to the transmitting distance and most systems have a range of 20 km. When using WDM-PON, the splitter is replaced for an AWG (Arrayed-Waveguide-Grating), a wavelength demultiplexer.

A wavelength is now allocated to every customer. The result is practically full bandwidth for all. You may say, that you make a point-to-multipoint solution, but use it as a point-to-point solution, which is a great idea. The component that makes this possible is the AWG, which is manufactured by Ignis Photoniks, one of the biggest manufacturers in the world.

Ignis Photoniks, a Danish company, is predicted to have a promising future.

Figure 5

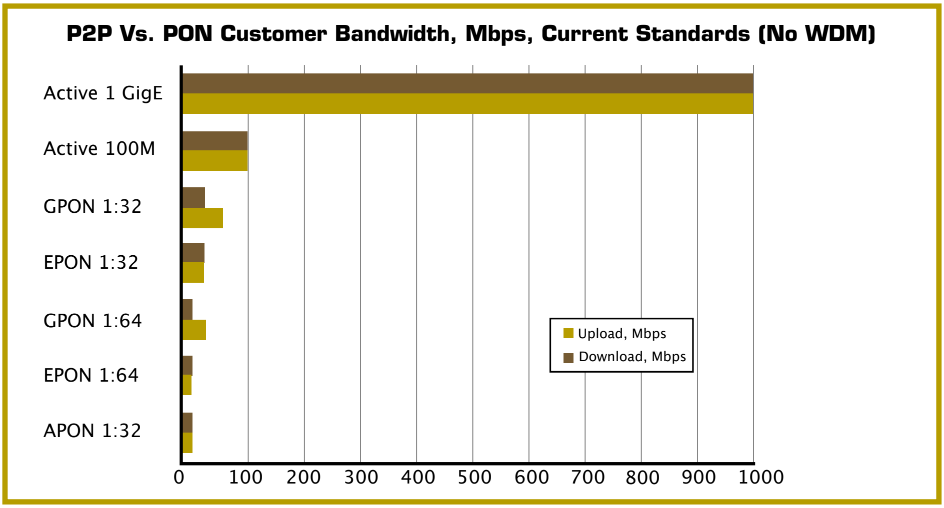


A WDM-PON System

It is a disadvantage, however, that all transmitters must be carefully tuned to a specific wavelength. Consequently, the costs are going up, but despite the rising costs, this may very well be the only way to solve the problems concerning the need for more bandwidth in PON systems.

Let us try to compare the two technologies, but bear in mind, that a lot of religion is involved.

	P2P	PON
Bandwidth	No limitations	Many limitations
Prospective possibilities	No limitations	Still limitaions concerning WDM-PON
Power consumption	High consumption - unnoticed by many	Less consumption than P2P
Fiber consumption	One fiber to everybody	The first length of the fiber is common - no cost savings, though, as fiber is so cheap
Duct consumption	Ducts to everybody	Ducts to everybody. No cost sav-ings, even though the first ducts are somewhat smaller
Testing	Testing is simple	Testing is very complicated. You will have to place connectors in street cabinets, which may not be the best solution
Connector consumption	One in the beginning -and one at the end of a fiber system	One shared connector in the beginning, one set on the way (in a street cabinet), and one at the customer. Thus the number of connectors is appr. the same
Patch cables	One patch cable each	Patch cables to 16 or 32 custom-ers. Cost saving, considering error possibilities, cleaning etc.
Trouble-shooting	Very easy	Very difficult
In case of errors in the access network	Affects one customer	Affects 16 or 32 customers
Demands on cleanliness	The same in both systems	The same in both systems
Space in access houses	A big need for space	The need for space is somewhat less
Lay out of access houses	Becomes easily cha-otic.Requires tidiness from the beginning	Does not contain so much equip-ment, therefore a much simpler lay out. Yet, errors disturb more custoners at the same time
Safety	Working with low powers	Working with high powers. Be aware of potential safety problems
Spreading	Widely spread in Scandinavia	Widely spread around the world
Geographical Coverage	Suitable for small areas (like in Denmark)	Suitable for longer distances
The price	Has not yet been agreed upon	Has not yet been agreed upon

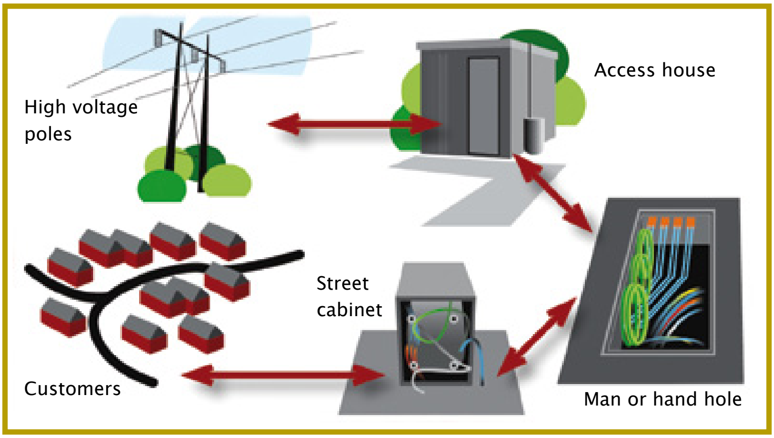


The figure shows P2P systems in comparison with PON systems, with regard to differences in bandwidth. These days, EU (European Union) is working on new legislation, intending to ban PON in FTTH installations in EU. The reason for this initiative is, that it is difficult to make an open system, with various service suppliers.

Building a complete FTTH installation

On the next pages I will show examples of how a complete FTTH installation can be made. The pictures are from around Europe and do not show a specific system, but show lots of the components which are being used. But is a typical setup for Denmark.

Figure 6

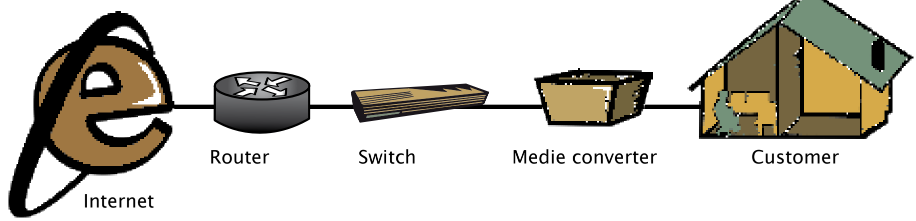


The Distribution Network

Internet, TV and telephone signals have to be transported around the country, laying cables can be difficult, some times ducts are buried, some times poles are used, but also the use of an exsisting high-voltage system, the high voltage cables(60Kv), connecting individual cities, may be utilised to distribute fiber. An example of this is OPGW (Optical Power Ground Wire), a high tension ground cable with fiber enclosed, providing a path for the transmission of voice, video or data signals. The OPGW cable consists normally of 24 or 48 fibers. Yet it is also possible to use the phase wire instead of the ground cable. Another option is to wind the fiber cable either around the phase wire or the neutral wire.

Figure 6

The principle of a FTTH installation



Driving across the Danish island of Funen, you may notice fiber wound around the overhead ground wire and if you are driving on the motorway, heading for Esbjerg, a Danish seaport by the North Sea , you may se fiber cables wound around the three overhead phase wires. Not far from Esbjerg, in the North Sea, is the small Island of Romo located. A dam connects Romo with the Danish mainland. The difference between the high and low tide is quite big here, so you have to be very careful, when planning to visit Romo, stay on the top of the dam, and you have no problems. Driving the car over the dam on your way to Romo you may see an OPFW along the road. The OPFW looks like any other overhead high tension wire, but on the way, you will notice a splice enclosure. It is not an exaggeration to say, that the connection to Romo is the most vandal resistant connection in Denmark. The voltage around the fiber is 60Kv. The following photos show how to make a full FTTH installation. This is only an example of how it can be made, as there are many solutions. The photos have been taken in Denmark, Sweden, Norway, Iceland and in Belgium. They reflect a way to build up an installation.

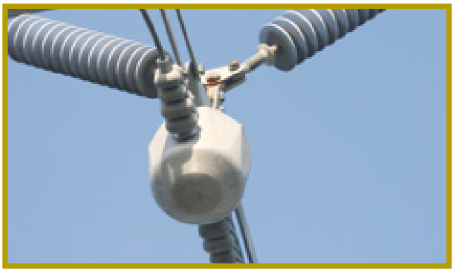
First of all we must have transmitted the tv, internet and telephony signals to the town. For that purpose we will use the high tension distribution network.

Figure 7

OPFW access to Romo

Optical Power Fase Wire is overhead wire with fiber enclosed – typically 24 or 48 fibers.

Figure 8



A splice on the Romo dam

When we have come to town, the fiber must be distributed. For that purpose a number of access houses will be set up. From the access houses, data signals will be spread to every resident in the town. The photos below show examples of different kinds of access houses.

Figure 9

An access house

Figure 10

Access house, another example

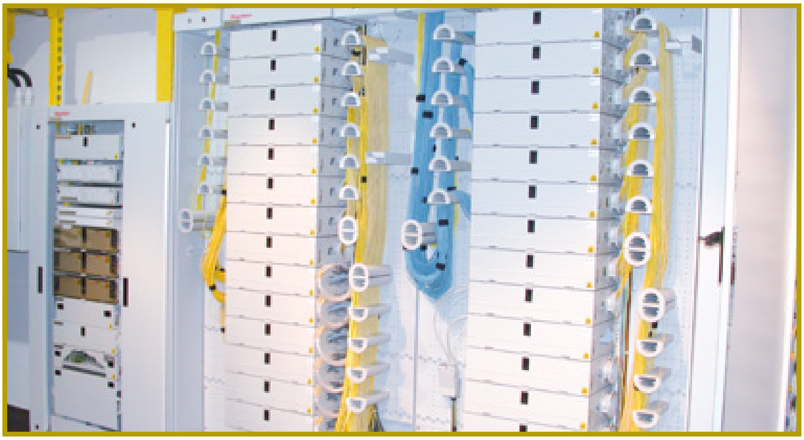
Figure 11

Access house – the designs are many

The purpose of the access house is to distribute the optical signal, and thus deliver the content to the many users.

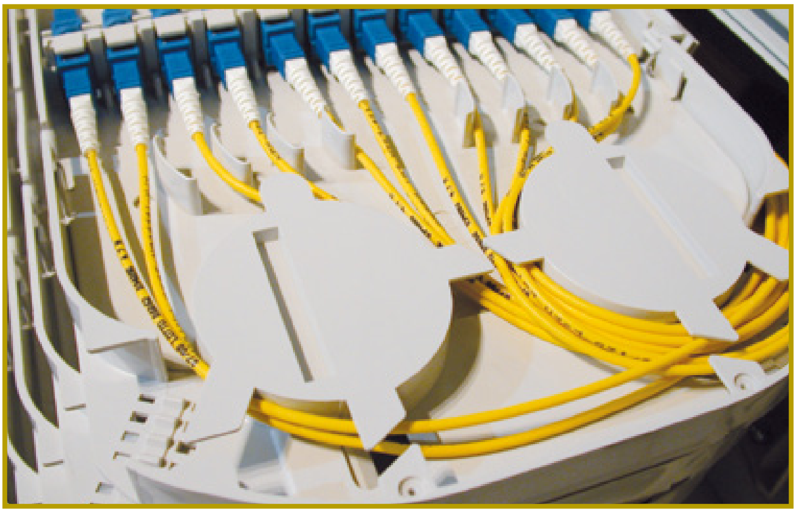
The purpose of the access house (also known as a POP) is to get the content to the area, the fiber optic signal is converted into an electrical signal, and put into the router, the router is good for transmitting over long distances. From the router the signal is transmitted (typically in fiber) to the switch. This component distributes the signals out to many customers. Lots of access houses in Denmark distribute signals to thousands of customers.

Figure 12



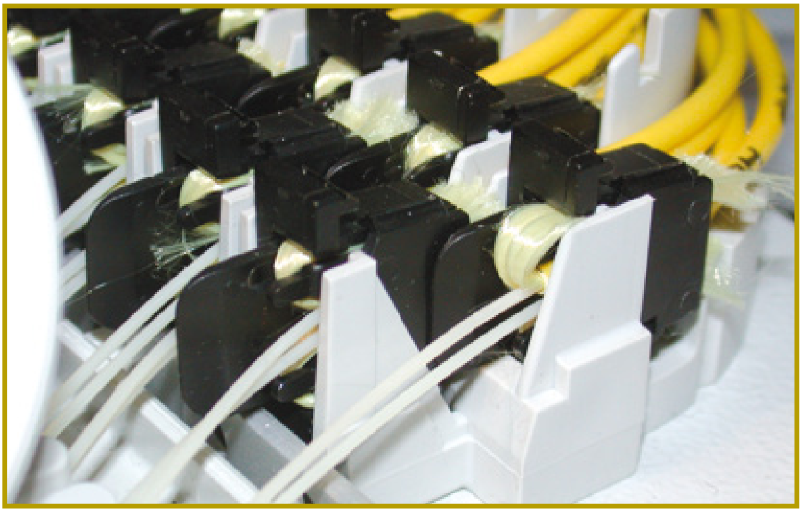
A large installation with Tyco components

Figure 13



A patch cassette. The fiber is patched to the active equipment.

Figure 14



An example of how to strain relieve fiber from tyco

Figure 15

A splice cassette from tyco

Normally, cables leave the access houses through 10 mm ducts enclosed by 40 or 110 mm ducts.

Figure 16

Cables leaving the access house

Figure 17

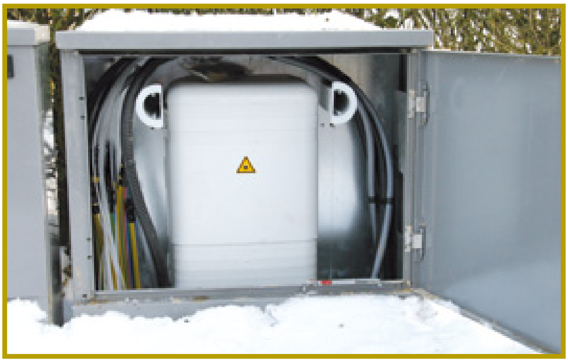
Another example of fiber cables leaving the access house

Figure 17 shows some micro cables (containing 72 fibers) on their way into a 10 mm ducts. Enclosed in a 40 mm duct, the ducts then continue to a manhole.

Figure 18

The first division is made in a manhole.

Figure 19



The fiber is divided again, in a half-buried street cabinet. From here, fiber is spliced to every individual customer. The spliced fibers leave the cabinet enclosed in a 40 mm pipe.

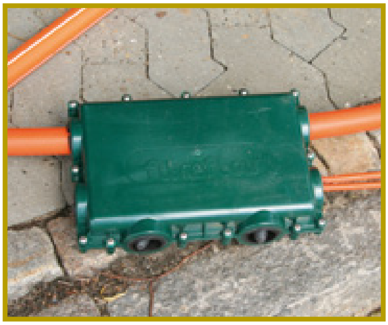
Figure 20

The picture shows the 40 mm duct and a fixed enclosure. Two 10 mm ducts have been separated and from here they will be taken to the customer.

Figure 21

Another way of connecting customers (see figure 20). Here the connection is made by means of a taped enclosure (Erikson). The enclosure consists of self vulcanizing tape. If made correctly, the enclosure is 100 percent waterproof

Figure 22



Example of a breakout enclosure from Emtelle

Now the duct must be taken into the house. Some companies chose to mount a terminal box, which makes it possible to measure the installation from the outside, so you do not have to trouble the customer inside the house. Others chose to take the fiber below ground level, to hide the installations.

Figure 23

An example of how to end an installation close to the customer. The media converter may be placed in different places – in a cabinet, a technical room or in a utility room. Some problems concerning the location may occur, as you have to consider a duct from the street outside. You also have remember that from here you need cables for tv, telephone and computers.

Figure 24

This is a set up box, being able to convert an IPTV signal into a usable tv signal.

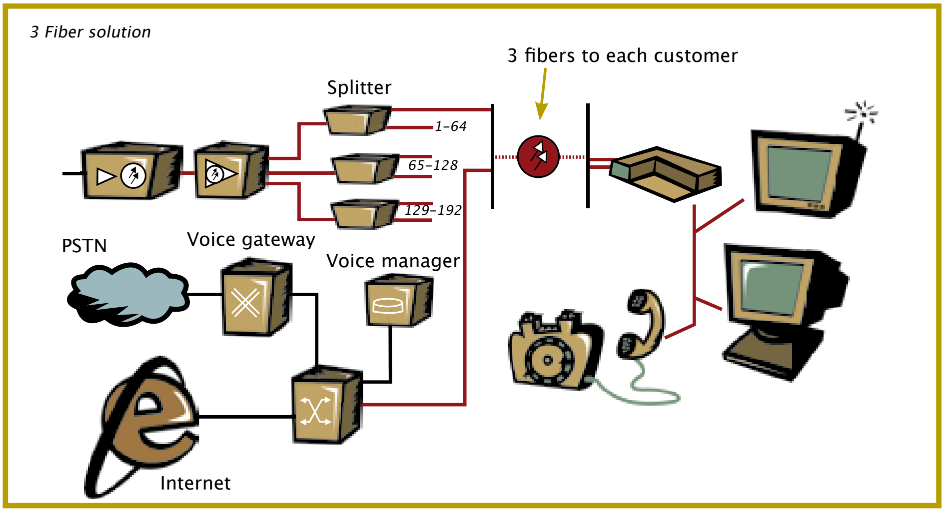
The Technical Part

There are several possibilities, when making the system.

Three fiber solution

In the old days 3 fibers were used. Typically, multimode for the Internet connection. From the Internet to the customer 850nm (one fiber, download), and from the customer to the internet 850nm (one fiber, upload). For the analog TV, single mode fiber at 1550nm. After the drop in price of single mode components, the signals for Internet are transmitted at 1310nm. The telephone signal is transmitted as IP telephony on the Internet fibers, and thus needs no extra fiber.

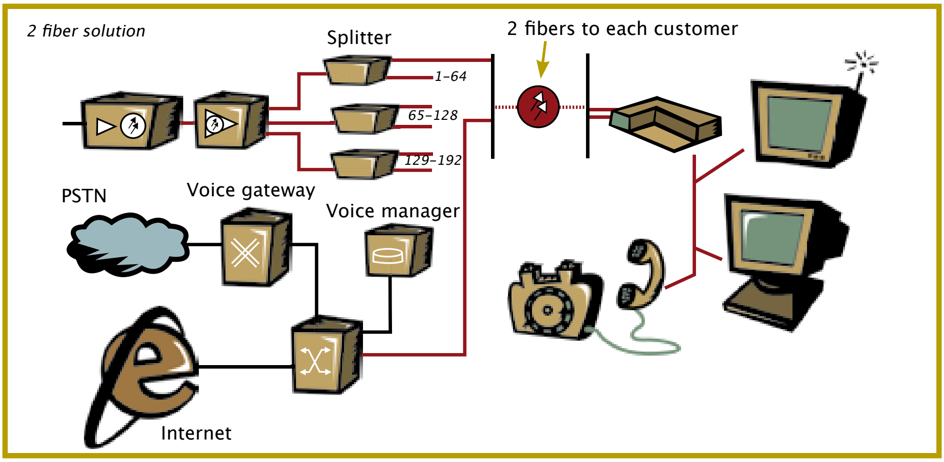
Figure 25



Two fiber solution

The next generation uses only two fibers. Only one for Internet connection. 1550nm transmitting towards the customer, and 1310nm transmitted back from the customer. There is no problem having the two signals at different wavelengths in the same fiber. It's a bit like the different colours coming from the TV, and not getting mixed with each other. The TV is still transmitted at 1550nm.

Figure 26



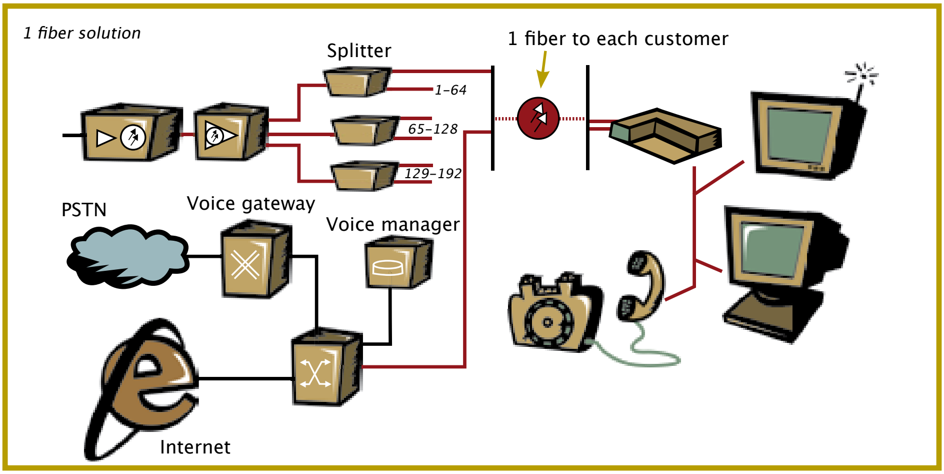
One fiber solution

The latest development is a single fiber solution. Analog TV is transmitted towards the customer at 1550nm, Internet to the customer at 1490nm, and the return Internet from the customer at 1310nm.

The best solution

IP to the customer at 1550nm, and 1310nm return from the customer. Internet IP telephony, and IPTV are all transmitted as IP signals.

Figure 27



By 2011 og 2012 it is expected, that the whole of Denmark will be connected to the Internet by fiber.