Telefónica
since 1924

Copper network switch-off

Pablo Ledesma and José Luis Correa

1. Why is copper there?

In 1924, Telefónica de España was founded to provide telephone service to the citizens of this country. The basic idea of how voice is transmitted from your home to the home of the person you're calling is pretty simple: Let's imagine the city of Tarragona.

From every house in Tarragona there is a small copper cable that runs down the street through different pipes and poles to a telephone building that is called “telephone exchange”. From that telephone exchange there is another little copper wire that goes to the house you are calling. The miracle is complete when you dial the number of the person you want to call, and at that moment there is a physical communication between that little cable that you have in your house with the little cable that your family or friend has in theirs.

There are several things to qualify in this short explanation: the first is that it is not one copper cable, but two. This little copper cable that goes from your house making a trip under the city and up poles to the telephone exchange is called many things: copper pair, subscriber loop, line... But for simplicity's sake, we'll just call it a loop.

Secondly, the telephone exchange is not just a building, of course. Inside the exchange there are machines that are capable of switching from your loop to any other loop that you want to call from that exchange. At first, this operation was done manually by an operator, but little by little this activity was automated and digitized, so that human intervention was not necessary. We will call this exchange the “switching station”. Logically, all the switching centres in Spain are in turn linked by another network so that if you call a person who is not in your neighbourhood or is not in Tarragona you can also communicate with them.

Finally, it is very important to understand that the loop could not be very long. Why? For a thing called attenuation, which I'll explain in a very simple way. If you go out to the window of your house and shout to your neighbor, the neighbor across the street will hear you, but three blocks away they won't hear you because your voice is muffled by the air. It's exactly the same with your voice as it travels through the loop. That is why in a city like Tarragona that we have chosen as an example, there is not just one telephone exchange, but there are six that cover the entire city of Tarragona as if they were superimposed polygons. As a curiosity, it may be that the neighbor you see when you look out your window depends on a completely different central office than yours.

2. Why did copper stop working?

With this magic of communication called looping and with switching centers, Telefónica has been providing voice service for 65 years. But in 1983 a thing called the Internet was invented that allows, as everyone knows, to communicate data between computers. Now it's not just communication between computers, but between all kinds of devices. In Spain, the first internet connection was made in 1990. The first thing that was tried was to use that same loop to transmit the Internet and in fact it was achieved, but the speed of data transmission was not very fast and the need will grow year by year, so that the copper loop did not serve to transmit all that information that was necessary to transmit. I'm sure you remember connecting to infovía and listening to your phone beep. That was the internet stream that was initially used. Then came ADSL, which stands for the "Asymmetric Digital Subscriber Line". This technology was used for the first time in Spain in 1999 and allowed Internet to be transmitted from the exchange to any subscriber loop, but it had a basic problem: the length of the loop determined how fast the information reached you.

Once again, attenuation makes its appearance in copper and although many other technologies were improving the ability to send information, such as VDSL (Very high-bit-rate Digital Subscriber Line), they were unable to go further. Taking a cue from the scream out the window, the VDSL allowed you that the one in the front window to hear you louder, but three blocks away you still couldn't hear you.

So, the old copper network made up of that loop and those switchboards had a second life by popularizing the use of the Internet through ADSL. As I mentioned earlier, the copper loop was providing voice service for 65 years, and until today it has been providing voice and internet service through ADSL for almost 35 more years. That's a lot for that fine copper pair that's in all our houses, isn't it?

But the need for Internet speed has continued to rise at a rate nearly doubling every year since that first connection in 1999. At first, we settled for speeds of 128kbs (kbs stands for kilobits per second, which is the measure of speed of sending information typically used on the internet). Just 6 years later we were aiming for speeds of 30Mbs (256 times faster than in 1999) and that speed could only reach 50% of our beloved copper loops. Too great a limitation: We are facing the end of the copper network.

It can be said that it was the internet that signed the death warrant of our old and noble copper loop that has been serving us today already for hundred years.

3. Fiber-to-the-home is the copper loop substitute

Telefónica began to look for an alternative to the copper loop to be able to provide the internet service that society was demanding. In 2005, Telefónica put the first connection

in Pozuelo de Alarcón of something called FTTH (Fiber to The Home), that is, from Fiber to the home or simply "fiber". Fiber optics is the modernized cousin of our beloved copper loop, with a few differences, of which I'll highlight two for now. First of all, fiber is a single strand of fiber optics that connects your home to the telephone exchange, when the loop was two wires. And, secondly, fiber is a means of transmitting light, that is, pulses of light are emitted from your house to the central and in the opposite direction as well, and this is how information is transmitted. In the copper loop they were electrical impulses. But in the end, the magic of communication remains the same: there is a hair of fiber optics (the caliber of fiber is similar to that of a hair on a human head) from every floor of every building in every city to a telephone exchange, and this is how we all get connected to the internet. In 2008 there were about 300,000 homes that had fiber coverage out of a total of 16 million at that time and this test served to understand a number of key advantages that fiber to the home had.

In the years between 2006 and 2009, and after many discussions, Telefónica decided to deploy fiber optics on a massive scale in Spain as an alternative to our old friend the copper loop. And I say after more than a few discussions because first, there were much cheaper alternatives at that time (but less durable), and second because this decision is no small bet on a multimillion-dollar project that would last more than ten years and in the midst of the 2008 financial crisis. I want to point out the importance of this decision, since the reader is perhaps not aware of the pharaonic work involved in carrying a little cable "again" from each of the houses of this country to each of the telephone exchanges.

Telefónica has undergone many technological transformation processes. We had a copper loop for customers and manual operators, and one day the operators were changed to automatic exchanges. We had automatic control units and one day they were replaced by electronic ones. We had digital exchanges and the internet came along and we connected it to those loops. We changed from digital exchanges to IP exchanges. All these transformations, although obviously complex, consisted of changing elements in the control unit and from one day to the next "changing" the copper loops and connecting them to a new device. However, what makes the project of transforming the copper loop into the fiber strand particularly singular, complex and unique is that, for the first time ... What we change is what we call "access", that is, that immense network of cables that travel from each house to each power station. This difference is subtle, but very important, because it is the one that requires a long transformation time to reach the completeness of the coverage of the target perimeter of loops of a specific power plant and another indivisible difference from the previous one is that it is necessary to access the home of each customer.

Anticipating the facts a little, the pharaonic work is even grander if we think that we are going to finish deploying that fiber - I insist from every house to every power station - in approximately 16 years. In 2005, the copper network had not reached all homes in Spain after 80 years.

And why fiber to the home? There are a few characteristics of fiber that, as opposed to those I have mentioned of copper, are important for understanding the beneficial effects of copper.

- The first benefit is that fiber optics do not have the attenuation that copper has, so that the entire city could be reached from this central station in Tarragona. In other words, if there are six power plants in Tarragona right now, we could only keep one with fiber.
- The first benefit derives from a very obvious second: fiber provided better service to customers since the Internet speed with fiber could be much higher. We soon discovered that it was particularly beneficial to certain groups such as those who lived somewhat far from the copper switching station.
    - I remember an anecdote of a customer who lived in front of the Bernabéu – the centre of the world for many – and didn't understand why his internet speed was so bad and on the street across the street so good. If anyone knows the situation of the Bernabéu stadium, they know that it is next to a very large avenue that is the Paseo de la Castellana and the headquarters of this client was on the other side of the Castellana, it went up 1 km to a roundabout and went down again so that indeed, the Internet speed that reached it with ADSL was very bad. The day we put the fiber in it, which coincidentally went the same way as its cousin the copper loop, it literally saw the light of day.
    - This case of long loops is very common in villages and districts. In those towns, there was often a copper line that worked very well for voice, but it had never been able to provide Internet. Getting to these types of towns and districts is not easy, since you have to travel longer roads, mainly by poles, crossing land of hydrographic confederations, for example, which have to give you permission to do so. The next time you're traveling down a highway and you see a line of poles to your right or left, remember that along that line we're being able to bring internet to the towns you're going to.
    - Another paradigmatic case was that of the "gamers" who, when fiber optics started, quickly jumped on the bandwagon because when they played online with other players, the lower latency of fiber always allowed them to win over those who played with ADSL... They literally drew and shot faster than the opponent (latency somewhat similar to speed, could be called reaction time, but for the sake of not going into details we leave it in the anecdote)
- The third benefit to me is that fiber is a future-proof loop. I want to tell you with this that by simply changing the equipment in your house connected to fiber and the one in the telephone exchange connected to fiber we can increase the speed of the Internet, almost without any problem, that is, if the copper loop had lasted 80 years by the time we started deploying fiber, It could possibly last 200 years. Yes, what Telefónica and other operators have done in Spain is going to be here with us for many generations providing service.
- Another advantage of fiber is its energy efficiency and its efficiency in the space occupied by the equipment in the plant. We have already said that where there were six power plants we could leave only one, but in that plant that had several

floors only one floor is enough. In addition, the electricity consumption of fiber equipment is 10 times lower per megabyte emitted than copper equipment.

- And finally, it is very relevant that fiber has fewer breakdowns than copper. Simply to highlight a very common one, copper is affected by water so that when there is abundant rain and the cables that go under our streets get wet, they break down, and fixing them is not an easy task. Fiber doesn't care about water. Suffice it to say that, on average, a fiber has half as many failures as a copper loop.

For these five reasons and many more with which I will not tire the reader, Telefónica accelerated its fiber deployment and plans to finish it in 2024, coincidentally, or not? Just as the old, old copper network turns 100 years old.

4. The copper shutdown: from vision to reality

As the reader will have already glimpsed, being able to fully deploy the fiber network allows you to turn off the copper network. This concept, copper switch-off, did not begin to be thought of until 2014, when it began to be observed that, in certain copper switching stations, all the houses in that neighbourhood had already been covered, and therefore, the possibility of closing them was thought of for the first time.

The benefits of shutting down copper power plants are many, but let's look at three in particular:

- Economic. To maintain two networks forever, or in other words, to have a network that is not providing service to anyone, does not make sense. It's like if you switch PCs at home and always keep both on and don't pass your information from one to the other. Why did you buy the new one?
- Benefit to society. We have already mentioned that fiber provides better service and reaches much further where the internet has never reached before. Telefónica could have stayed in deploying fiber only in the big cities and keeping the copper in the rest, but it decided to turn off the copper to leave a fiber loop to most homes in Spain that will last 200 years, that breaks down less and that just by changing the equipment at home will allow us to give more and more internet speed to the grandchildren of our grandchildren.
- Environmental. The equipment in the power plants consumes energy and shutting it down means considerable savings. Fiber consumes much less energy per Mbps emitted, specifically 10 times less. Copper can be recycled. The fiber breaks down less and halves the trips we make to fix the copper when it breaks down.

As you can see, the benefits of copper shutdown are many and that is why a whole transformation process was initiated that allowed us not only to deploy the new network, but also to think about shutting down the copper network. A very bold decision in my opinion was to create a work team that only had to think about how to do that shutdown, a group of committed people who conjured themselves around a purpose: "turn off to light". The project was called "Faro". Culturally, this is a big step, since the organizations that deploy the network of Telefónica and any operator in the world are specialists in

creating a network, but it is not a main part of the culture to shut down, and for the first time it was proposed to do it in an industrial way.

5. The first shutdowns

The first two plants in Telefónica's copper network to be closed were those in Sant Cugat del Vallès (Barcelona) and Torrelodones (Madrid) in 2015. In order to do so, it was necessary to negotiate with the National Telecommunications Market Commission (CMT), now the National Market and Competition Commission. Why? Because Telefónica, on the occasion of the liberalization of communications in 1998, had to give access to the rest of the operators to its exchanges and there were many operators in our exchanges providing service to their customers using the loops that Telefónica had deployed in the past under a monopoly regime. For this reason, Telefónica could not unilaterally close a power plant and leave its competitors without service, and in order to regulate closures, the CMT established a special regulation for the closure of copper power plants. That regulation consisted of something very simple: Operators had to be notified five years in advance that they were housed in a plant before shutting it down. The first two large plants that had competitors hosted were closed in 2021 in Clot (Barcelona) and Hermosilla (Madrid). In the event that there were no competitors housed in that plant, as is often the case in small plants in villages, it was sufficient to announce it a year in advance. The first two plants mentioned at the beginning of the paragraph were from this second case.

6. The cycle of a copper power plant shutdown

In order to be able to shut down a copper power plant, several steps have to be taken first.

- The first thing is to deploy the fiber network so that every building, every house, every commercial premises, every home in that plant has the possibility of that little piece of fiber reaching its premises. I will not dwell further on the implications of this work of pharaonic engineering, in which we have encountered a multitude of difficulties. But I do want to highlight perhaps the only advantage we had: in Spain the engineers who brought the copper loop to each house did so through a series of conduits wide enough to fit the fiber in the same place and that allowed us to deploy better and faster. In Germany, for example, each deployment is requiring a new pipeline with the effort that this entails. And besides, we already knew the way to go to each house: we just had to follow the copper.
- The second, and possibly the most complicated, is to migrate all the customers of that exchange to fiber. Here the key is the word "all" because until the last of the customers has migrated, you have to keep the exchange running. At first, the law of supply and demand makes households and businesses decide on their own to switch to fiber, and little by little the percentage of customers who leave their copper loop unused is higher. But as much as 80% is a very high percentage, it is not enough to turn it off. For this reason, the migration of "the last" is undoubtedly one of the most complex tasks of conviction there is.

- The third step is to inform the CMT (now CNMC) of the date of the shutdown so that everything is carried out in accordance with the regulation. This step is very simple: just send a communication.
- The fourth step is the "moment of truth", i.e. the day you turn off the service to your customers. No matter how much customers are told to migrate to fiber – for the same price – because the copper service is going to be turned off, not always 100% of them do so. There are many causes behind this, from inertia, laziness and disbelief, but the fact is that in a few switch-off switches we have left a handful of customers without service. It must be said that when they lose service, most customers call and sign up for the new fiber service.
- Finally, the last step is to shut down and proceed to capture the benefits of that shutdown.

7. Capturing the benefits of shutdown

7.1 Circular economy

One of the first things we realized when shutting down power plants was that as we dismantled the elements of the plants, these elements could be used as spare parts for the repairs of the plant that is still in service. In other words, we stopped buying spare parts and did not throw away the parts, but they were used to fix the copper power plants that are still in service. We started training the circular economy.

Another element that we discovered about the circular economy was that we had buried all the copper that we had been deployed for more than 80 years and that it was no longer in use. Copper is a precious metal and has a lot of value. In addition, it so happens that the copper in our loop is of very good quality. At Telefónica we had no idea about the quality of precious metals, but we had to learn to see how we could recycle it and reuse that copper and start an exciting circular economy project.

The project simply consisted of taking all those copper cables that went to each house and extracting them, typically under the sidewalks, from the pipes through which it had been inserted dozens of years ago and taking them to recyclers who would melt them down to give other uses to that high-quality copper. Actually, the story is not as simple as I have told it in the previous sentence, but I would like to explain it a little in more detail to give the reader an idea of the complexity of what I am talking about. If we imagine the copper wires of each house, which travel under the ground and gather little by little as they approach a power plant, we can imagine these cables as a tree in which the very wide trunk is close to the power plant and branches open to reach each block and then much smaller twigs to reach each house. Let's imagine a power plant with four trees coming out, one to the north and one to the south, one to the east and one to the west. If the power plant is already completely turned off because the whole neighborhood has fiber, we proceed to cut the trunk at the base and then follow branch by branch under the ground to cut very close to the buildings. This seems simple when we think that the entire plant is turned off. But we soon realized that there were possibilities to extract the copper long before the plant was shut down by doing a lot of engineering work. It's as if we know that part of the tree branch is already dry and we cut off only that part.

Suddenly, we became underground tree trimmers in a mammoth engineering project. When we finish extracting all the copper that Telefónica buried for 100 years, we will have extracted 350 million kilos of copper cable, or 350,000 tons of copper cable. The Eiffel Tower contains 7,300 tons of metal, so we will have extracted the equivalent of 50 complete Eiffel Towers from beneath our towns and cities.

7.2 Energy savings

Another interesting benefit of copper shutdown is the savings in energy consumption. Telefónica consumes approximately 0.7% of Spain's total energy consumption. Yes, having internet at home means that there are many exchanges and many mobile phone stations with many devices on and consuming energy. In addition, these devices dissipate a lot of heat, i.e. they heat up, and therefore need to be cooled. All Telefónica exchanges have air conditioning equipment to maintain a temperature that does not damage the equipment that serves to bring internet to our homes. Specifically, there are about 16,000 air conditioning machines in Telefónica's total number of exchanges.

As we have already explained, by turning off copper we will have three benefits that directly mean energy savings:

- The first is that we will be able to do without many of the buildings where the power plants are located. Specifically, out of 8,500 plants of all types and sizes, we will be left with only 3,000 plants, which are necessary to provide service to the whole of Spain. Cooling 3,000 plants logically requires fewer climate machines than cooling 8,500.
- The second is that in the plants where we stay, we don't need all the floors, as we have already mentioned. Cooling a single floor cost less than cooling all of them.
- And thirdly and finally, obviously turning off the equipment that emits the electrical signal through the copper loop so that voice and ADSL internet reach our homes saves energy. We have already mentioned that, in addition, fiber equipment needs 10 times less energy to emit the same Mbps that reach our homes.

Therefore, and as with the circular economy project, Telefónica was immersed in an industrial energy efficiency project of astonishing dimensions. As we have explained in the copper extraction, we soon realized that we did not have to wait for the complete shutdown of the plant to save energy. Following the example of the tree that has part of its branches dry, we were able to prune that area and extract the copper. But also, from the trunk of the tree – from the central – we no longer needed to feed so many branches with internet sap, so we could turn off part of the voice and internet equipment. We call this exercise compaction, and it has allowed us to anticipate the benefits of shutdown in terms of energy savings. To give a figure of the dimension of compaction, in December 2022 we had completely shut down about 1500 plants (17% of the total) but we had already shut down 75% of the equipment that we did not need within the plants due to compaction.

But that's not all: having less equipment in plants means that there is less equipment dissipating heat, and therefore less need for climate machines. In 2022 alone, we

switched off more than 1000 air conditioning machines with the energy savings that this entails.

And finally, obviously, when we have already closed the entire copper plant, the shutdown means a final incremental saving. We have to distinguish two cases: those plants in which we turn off the copper and which are one of those 3,000 plants in which we are going to keep the fiber. In these plants, the savings are considerable, but we still need part of the space and air conditioning for the fiber. And the second case is that of those plants in which we do not leave any equipment on. In these cases, the savings are 100%. We practically turned off the light and locked the door.

So, in addition to pruning trees, we become energy savers. To give an idea of the magnitude, Telefónica's consumption is equivalent to the energy consumption of La Rioja for an entire year. The savings from switching off copper will mean the equivalent of saving almost 3 months of bills per year. Not bad at all, especially given the state of the energy market lately.

7.3 Fewer buildings to maintain

Of the total of 8500 power plants, we are going to keep about 3000 of the fiber. Many of these plants that we will abandon are cabinets that were in the street, which we will remove 100% or booths in villages. But some of these plants are large buildings in the middle of the city that we have been able to abandon altogether. In December 2022 we had delivered 13 centrally located buildings in cities such as Madrid, Barcelona, Seville, Bilbao and Zaragoza to different buyers. Some of them are very emblematic, such as the Buenos Aires building in Bilbao. In addition to the obvious economic benefit of the sale of these properties, there are also savings in not having to maintain these buildings in many facets: from the façades of the building itself, to the maintenance of the elevator, security, cleaning, toilets, and the relevant health inspections. from the payment of the IBI..., to the mere fact of being able to completely turn off the energy of the building by extracting from it all the equipment, not only telecommunications but also power. Emptying a building of all the electrical material, cables, transformers, telecommunications equipment, refrigeration machines..., in order to be able to deliver it to the new owner is another industrial project in which we had to become experts.

In addition to pruning trees and turning off lights, we became interior designers, with large open spaces and, yes, building salespeople.

8. Conclusion: A legacy for many generations

A fiber network that reaches where copper has never gone before, that needs 10 times less energy to operate, that will be able to continue to increase the speed of the internet for our grandchildren's grandchildren, that has made it possible to recycle 50 high-quality copper Eiffel Towers, that saves a third of the electricity bill, that it has returned emblematic buildings to the cities for another use and that half of what the previous network did is a good legacy. A magnificent legacy that is the result of the ingenuity and commitment of many generations of professionals.

Telefónica decided to deploy, in the midst of the financial crisis of 2008, a new network that has left our country in a historic place as it is the first telecommunications company to close its old copper network and at the same time bring fiber and therefore high-speed internet to all corners of Spain. Let us hope that this legacy will be used by future generations as a competitive advantage over the rest of the countries of Europe and the world.

www.telefonica.com