

GUIFI.NET

Neutral, Open and Free Network for everybody

Laura Álvarez
Ferran Quer
Maite Intxausti

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1. Introduction

1.1. Freedom in telecommunications

The concept of freedom in telecommunications is basically attached to the free software (so you can use it), open hardware (to be able to apply it), open standards (to be able to understand them), free contents (for sharing) and the open network (to be able to communicate).

As the communications are present everywhere, nowadays these concepts are very common; but like open network's essence is material, it's harder to develop them than the free software for example.

However, nowadays, although the connection to the Internet is becoming necessary for basic operations in our way of life (bureaucratic procedures, university enrollments...), it's still a luxury: the ones that can't pay the high monthly fees that offer the traditional companies are excluded. So many people think that it's necessary to find an alternative to the traditional methods.

The possibilities that technology of wireless data communications offers have led to make multiple kinds of wireless networks initiatives (private, community networks...), not so oriented to provide wireless connections at home but to connect with the neighborhood and be able to share resources and services. As those initiatives are not under the control of a business that wants to make profit, they only know the limits of technological possibilities, imagination and the ability of each one.

The aim of guifi.net is to share this infrastructure and provide organizational mechanisms to operate and manage. It's not a company, neither private nor governmental, oriented to provide a public or paid service, but simply matching a common interest of a group of people and to which everyone is invited to join.

1.2. An open network

An open network has two main characteristics: everyone can connect to it (there is no restriction that isn't natural) and it's neutral (nobody has preference and there is no restriction of the contents). In these networks we can get access to internal contents and also to external contents (contents in other network) through the connection to the Internet.

The differences between the traditional telecommunication companies and an open network like guifi.net are many: everybody, independently of her social condition and location can connect to the open networks and they haven't got a concrete owner, while the others have a restrictive access (a monthly fee); the open networks are symmetric, while the others aren't (the users can't provide services); the open networks are neutral with the contents, while in the others it's possible to have filters.

It's interesting to see that in open networks the users are the ones that build and maintain the network, and each one is owner of her tram: so there's not centralized control that can make restrictions, and also it makes them be conscious about making good use of the material and approaches the knowledge of these technologies to the users.

2. Guifi.net

Guifi.net was born in 2004 in the village of Gurb, near Vic (the name of the project comes from here: GURB + Wifinet). The parents of this project met to share ideas and plan the first tests: their aim was to create the biggest free an open network as possible by the users, leaving them all the material as they could.

For this historical reason, the most important nodes are near the first town they made their first tests: Calldetenes, Gurb, Santa Eugenia de Berga and Vic.

As we said before, the aim of the project is to create a “network of networks” that avoids the disadvantages that currently carries the control by the companies. It wants to be an “alternative Internet” where the users are the owners of the infrastructures and where everyone has the same rights and freedom. It's not a big multinational that owns the lines and rent the use of them under the conditions that it imposes, who limits artificially the velocity we get and the access to some services.

With guifi.net it is possible that any user can mount any kind of service, with no limit except the maximum speed that the created infrastructure can give, and an ethic code of use that allows to perform while it doesn't damage the performance of the network, the freedom of other users and while it respects the conditions of content and services that flow freely.

In summary, it's an open (everybody is invited to join), free (there's no owner that imposes his conditions) and neutral (the interconnection agreement is made between equals) telecommunications network that extends with the tram that every new user incorporates when she connects.

The companies that are interested in participating in the project can also join, providing outlays that simple users can't provide. However, there are many discussions about this in the community, as some people agree with giving some privileges to companies that make an effort to do an outlay, but others think that this goes against the principles of guifi.net.

2.1. The foundation

In 2008 a group of users of the network created the entity with no aim of profit called “Fundació Privada per a la Xarxa Oberta, Lliure i Neutral guifi.net”, which serves to manage legal aspects that may affect to the users of guifi.net; it's not the owner of the network, it has the respect of the users because of their beneficial performance.

Officially it's registered in the operators register, so it provides legal support that is necessary to perform with the same rights and duties that other operators have; hence, it can obtain permissions, make arrangements and notifications on behalf of guifi.net with the administratin or third parties, make interconnection agreements with other operators and many other privileges.

2.2. Funding

As we said before, companies that participate in guifi.net give an economical support in order to develop the network. However, the users contribute economically too, each one as she wants: the growth and maintenance of the network is done thanks to crowd-funding, using their web for it.

It's important to say that there are many volunteers that work on the project, and many actions are made by the users themselves as we're going to see in the next lines.

2.3. Local organization

The foundation “manages” the large deployments (as a new optical branch), but otherwise the users have to create their tram. If there is nothing around us and we want to connect to the network, instead of waiting like we would do in the case of connecting to a traditional operator, we have to act: find interested people near we live to work together, find a suitable place to put the super-node, open a crow-funding process in the web and mount it. To solve the doubts or to see other experiences there’s a forum in the web and we can ask to the other users.

2.4. The network nowadays

Since the project started, the network has expanded considerably. Looking to the figure 2, we can see that it happened not only in Catalunya, but also in other places of Spain. Although most of the nodes are in Catalunya, but there are some other places that have a considerable number of active nodes: mainly Valencia, Madrid, Galicia and Asturias.

In addition, in the next table we can see that there are some nodes out of the continent too (although still they are only a few).

If we look at the numbers, actually there are 26225 links that reach over 41232km. In the next graphic we can appreciate how has the network increased in the last years.

<i>Continent</i>	<i>Operative</i>	<i>Projected</i>	<i>In construction</i>	<i>Under test</i>	<i>Total</i>
<i>Africa</i>	3	18	0	0	23
<i>America</i>	9	103	2	3	117
<i>Asia</i>	0	7	0	0	7
<i>Australia</i>	0	0	0	0	0
<i>Europe</i>	22.289	10.160	355	516	35.124
TOTAL	22.301	10.288	357	519	35.271

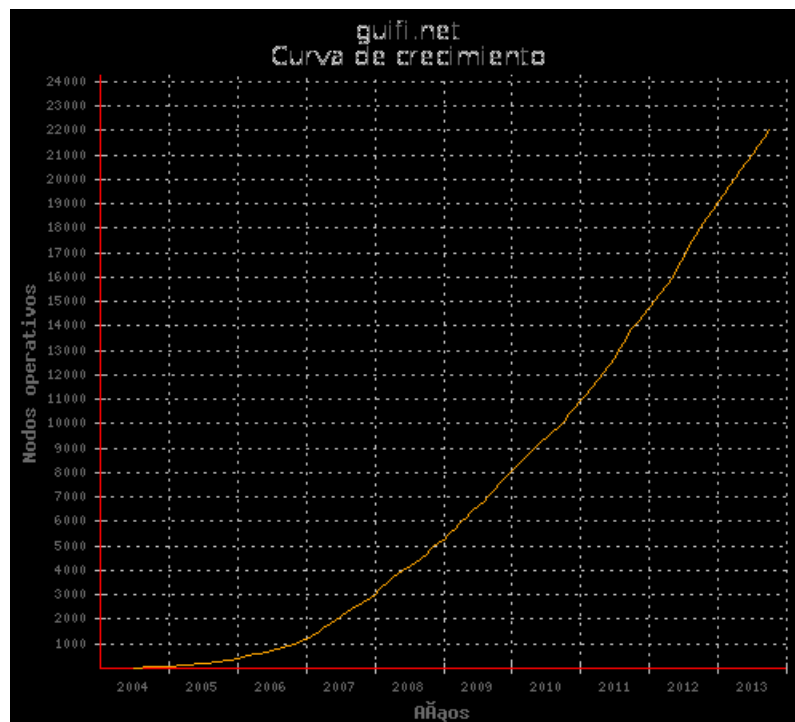


Figure 1: The number of active nodes increases linearly.



Figure 2: Guifi.net is widely expanded in Catalunya and País Valencià, but we can observe some other nuclei.

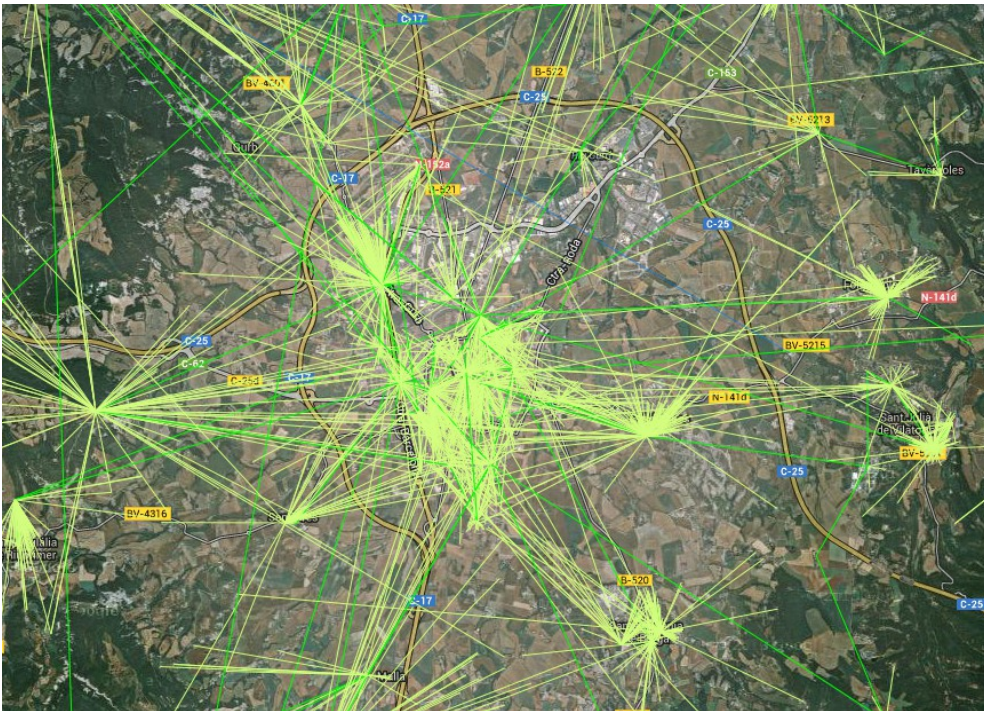


Figure 3: Guifi.net is strongly established in Vic, Gurb, and everywhere in their vicinity.

3. The network structure

3.1. WiFi / Optical fiber

In the implementation of the project, two technologies were considered: the WiFi and the optical fiber.

At the beginning the WiFi was chosen, because it doesn't need neither a big infrastructure nor permissions to work and the users can easily install the required equipment in a reasonable price. However, in the long term it requires a lot of maintenance, so the maintenance costs (COPEX) rise and the price/capacity ratio isn't as good as the one that optical fiber offers. This maintenance is in terms of climate and electrical effects on the equipment: lightings, strong wind, oxidation, etc.

The problems of using the optical fiber are its elevated initial cost (CAPEX), not only economical but also of the workforce and the permissions to place it, asking for permissions to local administration, highway owners, and in fact, to any land-owner whom property must be crossed. In urban areas, this implies either digging in the streets, or borrowing pipes from the city council. However, once it's installed, technical characteristics are much better than the WiFi ones and it almost doesn't require any maintenance. Therefore, the price/capacity ratio is higher, because of both costs, and its cutting edge capacity.

Considering this, the optical fiber is preferred when there is the appropriate infrastructure. Otherwise, the usual WiFi nodes are installed.

As a consequence, the guifi.net network is composed by WiFi-covered zones and OF-wired zones, which can interconnect, for example, in an operator's hotspot, providing connection by both radio and fiber. In the following two sections we describe the structure of each one.

3.2. WiFi

The WiFi network has a mesh topology in the backbone, and each node of the backbone (supernode), provides access to client nodes (nodes). It is formed by a backbone network that interconnect different supernodes, and by local networks, that provide access to client nodes. This nodes usually only connect to a single supernode in a local star shape, but can also extend the network.

Provided that the supernodes don't have much more information capacity than simple nodes, it is aimed to distribute the traffic among lots of supernodes. In conventional star topology networks, the supernodes have much more capacity than simple nodes.

The backbone is formed by point to point links, managed by the responsables of each of the linked supernodes.

3.2.1. The supernodes

Supernodes are the essential part of the guifi.net network, the nodes forming the mesh. They provide coverage to client nodes within a range of no more than 2km, using typical client antennas. As of supernode interconnections, they can reach 20km of straight line separation.

As far as the recommendations are followed, there is no problem in which antenna, router, and router OS is used in each supernodes. However, the newest ones are currently built using sectorial antennas with an integrated Mikrotek router.

These sectorial antennas have a 120° beamwidth, so in order to cover the whole plane, they are installed in groups of three.



Figure 4: Base Station Sector Antenna, from RF-Elements

3.2.2 Client nodes

The name “client” doesn’t refer to a service customer, but final user. Hence, they are also called “simple nodes” or simply “nodes”. These ones usually consist on a single sector antenna, in order to connect to a specific supernode. They don’t use more directive antennas not to discard other near supernodes, if they were to change the link.

A widely used antenna is the one in Figure 5, a model from SXT series, from Routerboard.

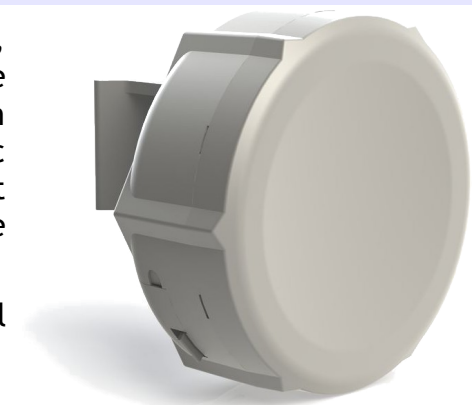


Figure 5: SXT series antenna from Routerboard

3.3. Optical fiber

The data rate transmitted by fiber are measured in Gigabit per second, is currently the medium of digital data transmission faster. They are the quintessential transmission medium to be immune to electromagnetic interference. It is used in submarine cables linking kilometer internet and are also used for short local networks.

In guifi.net fiber deployment has two challenges, the technology, easily manageable with a technical knowledge base, and, the largest, administrative.

For distribution backbone, will use an appropriate cable for outdoor installation with protective polyethylene dielectric (non-conductive) with 80 fibers, so that, allowing for specific bleeding from one or more fibers in each connection point, and also lengthen the leg, until in the future can be completed rings.

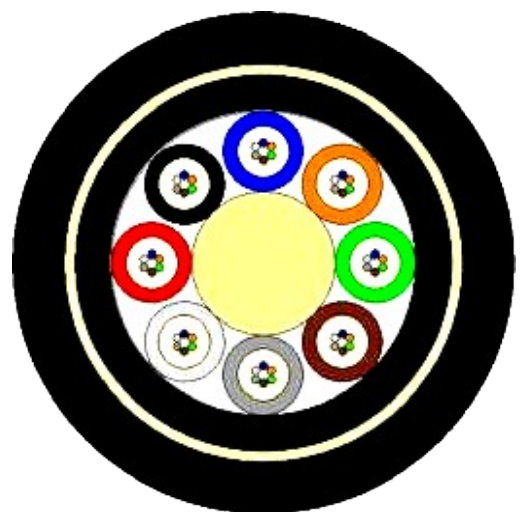


Figure 6: Section of a fiber cable

The features are:

- 10 tubes with 8 fibers each (total of 80 fibers).
- 15.4 mm diameter
- 125 m in length between poles
- 175 kg / km (17.5 kg/100m)
- Tensile strength of 4000N
- Crushing resistance 2500N/100mm

However, the wires used in Gurb area contain 96 fibers and the other properties may also differ.

The topology used is different for intercity and intracity connections: the intercity connections usually form a mesh network, the so called *backbone*, and the intracity connections usually form stars, the so called *user loop* or *last mile links*, centered in the nodes of the intercity mesh. Both kind of networks have two main parts: the active nodes (POPs - Point Of Presence, where all the electronics and logical configurations concentrate) and the passive optical fiber to make connections between the POPs and the users.

In the current guifi.net deployment, we only find examples of user loop, as the backbone needed to connect to internet is hired to another agent.

In section 4.2 we describe in detail the technology used in one deployment project.

4. Development of guifi.net

4.1. Historical evolution

Since the project started in 2004 the network has developed considerably and they've been awarded more than once: it should be noted that in 2007 they were given the National Telecommunications Award by the Generalitat of Catalunya.

In 2009 the foundation registered as a telecommunications operator in CMT (Comisión del Mercado de las Telecomunicaciones) and in the same year they deployed the first tram of optical fiber in Gurb (2km between 12 masies), after spending 2008 elaborating previous studies. Since then the optical part of this community network is being deployed in different sites of Catalunya. There are many other ongoing projects in Vic, Tortosa, Masquefa, Igualada, summing up 7 PoP's.

We have to say that despite the skepticism of some people about the capacity of community networks to incorporate the optical fiber technology, as we said, in guifi.net there are many ongoing initiatives to do so. The fact that some of these projects are already in the stage of being fully operational, bringing of 1 Gbps broadband Internet access to places (such as rural areas) where the traditional telecommunication companies are currently offering connections of few Mbs/s at most, proves that it is totally feasible to deploy and operate optical fiber infrastructure according to the community networks principals following a bottom-up approach; hence, the aforementioned skepticism is totally unfounded.

However, it doesn't want to be an isolated network. In order to connect other networks, in 2009 they joined the most important neutral punt in Catalunya CATNIX (the Catalonia Neutral Internet Exchange Point): this is the physical infrastructure that allow the different ISPs (Internet Service Providers) exchange Internet traffic between their networks. So this was an important achievement to connect with other networks,

although at the beginning they put some objections as they weren't a traditional company which use to join them. However, it has taken years to agree peering traffic with other ISPs: the peering process has been completed this year, so now the guifi.net foundation is peering with all the other CATNIX members with the exception of the big ISPs (Telefónica -the incumbent , Ono and BT), which haven't shown any interest in peering with them.

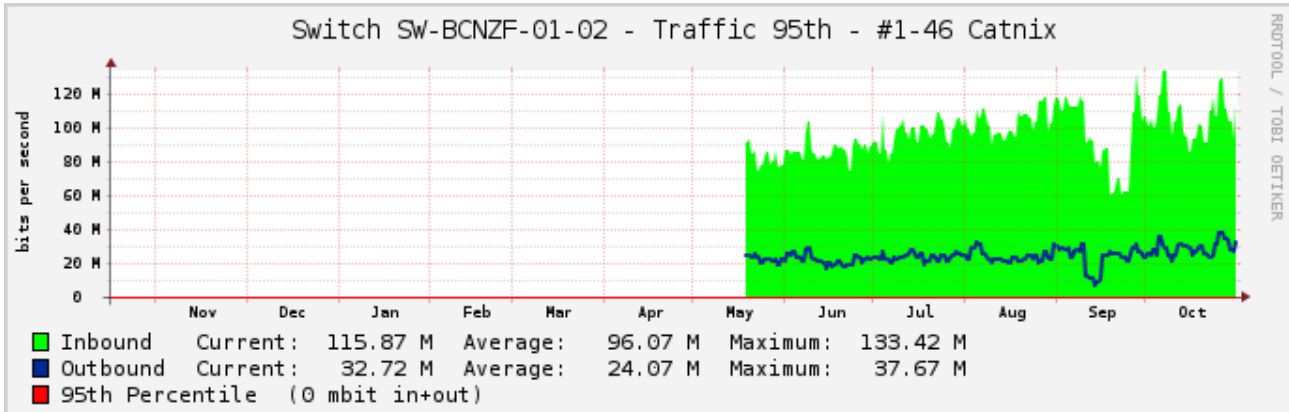


Figure 7: Input and output traffic of the peering port in CATNIX

Beyond this, from a general perspective, they're building a set of neutral ex-change points named POP-IX (Internet eX-change points), leaving the infrastructure available to the individuals, associations or either companies. Guifi.net's network of POPs is shown in the Figures 8 and 9

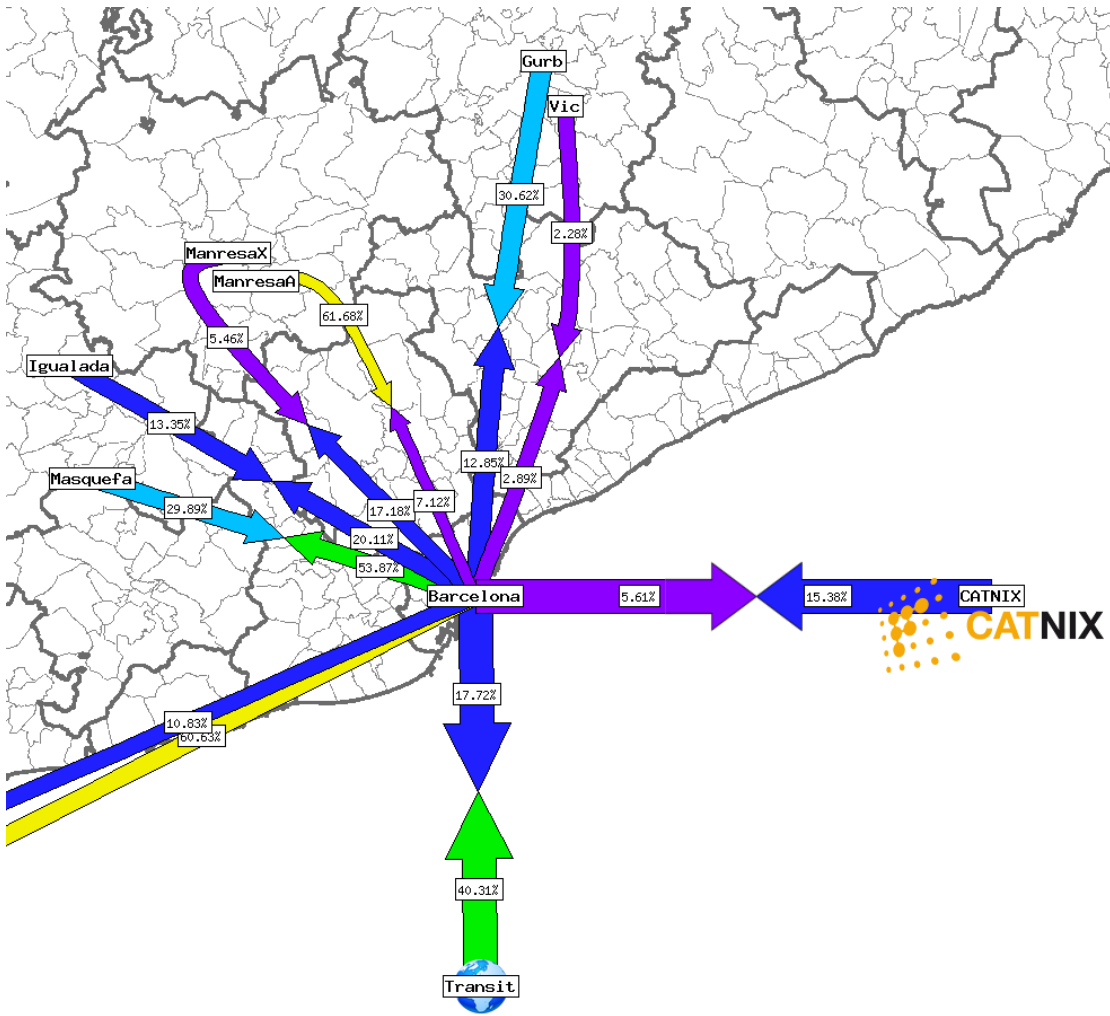


Figure 8: Northern PoP's

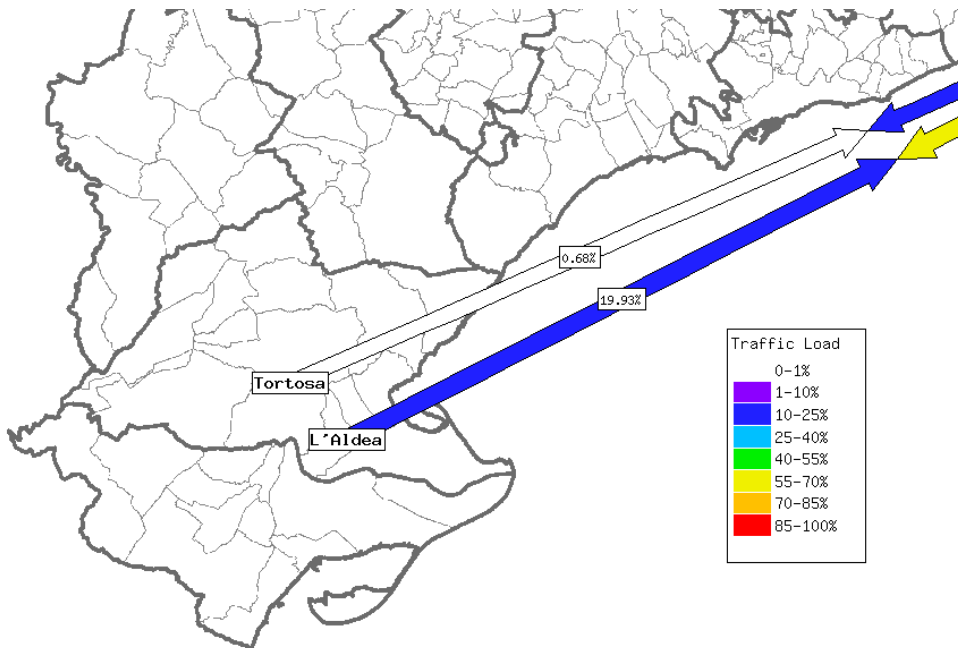


Figure 9: Southern PoP's

However, the backbone is so large that it's difficult to have their own infrastructure all the way, so mainly it's made using third party infrastructures. They have tried to agree with different organizations, but they've found many problems. In some cases, the owners of the so called "dark fibers" (unused fibers), because of some unknown reasons, don't want to hire them, so they put such high prices that nobody can pay for it. In the case of public administrations, there is an "open network" (XOC - Xarxa Oberta de Catalunya) which connects the different public administrations of Catalunya. But the concessions to exploit it are adjudicated by auctions, which is a questionable way to do it in terms of morality, because it benefits the most powerful parties. Actually, this network is mostly given to Telefónica, as in 2010 they signed a contract for 20 years. Even so, there's a small place for other companies and currently all the POP interconnection links are over the XOC.

Since last year, they're also participating in the project Commons4EU (Commons for Europe), which is a project where 7 cities participate: Amsterdam, Barcelona, Berlin, Helsinki, Manchester, Rome and UK-NESTA (UK cities involved in the project through NESTA). The aim of this project is to become these cities in Smart Cities, reducing the gap that separates the citizens of the new opportunities that Internet brought to collaborate: promoting the creation of a large base of commons in code, user generated contents and even telecommunications infrastructures with the emergence of Bottom-up-Broadband (BuB) networks. Guifi.net contributes in this last aspect, making once a year a report on the Pilots on fiber deployment that are carrying out.

Working on this new way of deploying optical fiber, they have defined a several new terms in those reports, such as Fiber From the Farm (FFTF-FFTx), a play of words referring to the active from vs. passive to role of the end users of the community network models and reaffirming the popular origin of the initiative farm vs. home; and also the commented BuB, characterized by the fact that the beneficiaries of the networks actively participate in the planning, deployment and maintenance tasks, representing a paradigm shift from a consumer-only position to an active and participant position.

4.2. Pilot project: Gurb

4.2.1. Evolution of the project

We'll explain how the pilot of Gurb has been developed as an example, because due to its success it has become a reference for the guifi.net community. It is one of the three pilot projects granted by the European Union through the Commons4Europe organization.

The Figure 10 illustrates the deployment of OF over the Gurb zone. It shows the current ones and the planned. It doesn't show the fiber of Vic although its zone appears in the map. The reason is that Gurb and Vic are different pilot projects, so they have different deployment maps.

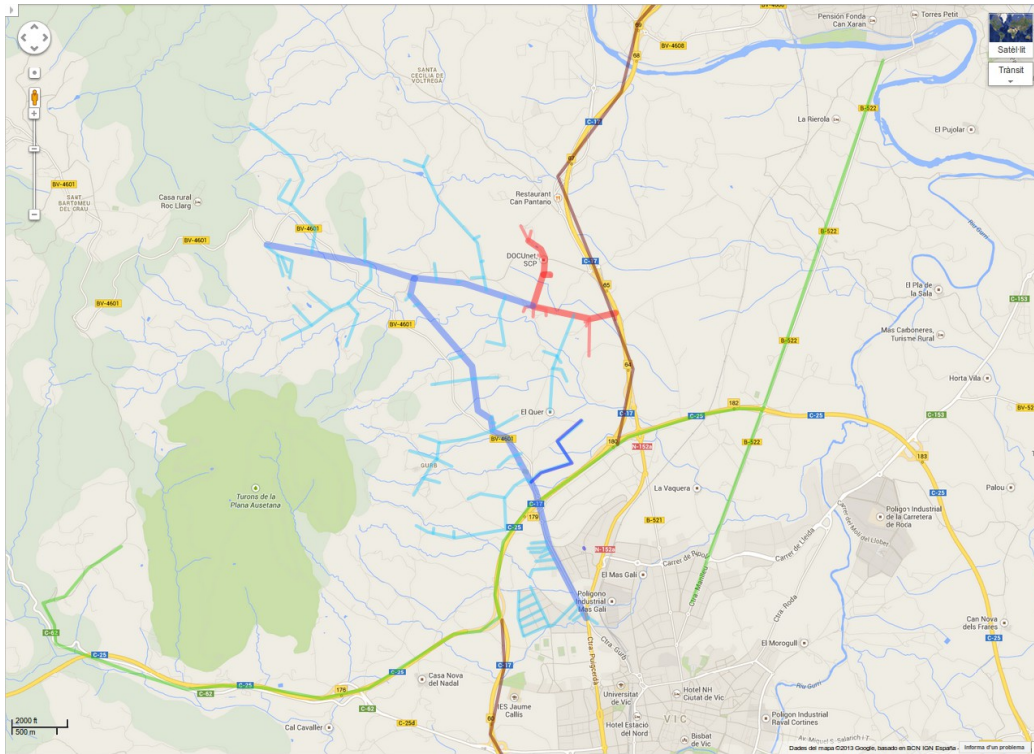


Figure 10: Map of the fiber deployment in Gurb.
 — Before 2013
 — During 2013 (backbone)
 — During 2013 (user loop)
 — Plan: by 2014
 — Plan: during 2014 (backbone)

Gurb is a typical Catalan rural village formed by a few streets and many disseminated farms, some of them rather isolated. As we said, guifi.net project was born in this village as a response of the people to the lack of Internet access. The local government has always been strongly committed to the project. Most of the buildings are connected to guifi.net WiFi network. In this village and in many others of the area guifi.net has become the standard mean to access the Internet. Local government ducts and dark fibers are available to be used according to guifi.net’s principals.

This was the first OF initiative in guifi.net, started in 2009. The deployment and the activation of the first iteration took place in 2010 (up to 24 farms were connected), and it was connected to the Internet in April 2011. Despite of the several obstacles found, most of them related to the novelty of the model, and the extra steps that had to be taken to circumvent them, thanks to the determination and the conviction of many volunteers the project was successfully carried out.

In 2012 the second iteration was started: it is being carried out as planned -three fourths of the users are already connected and the rest are expected to be connected before the end of the year.

The two first deployment iterations have proved that the BuB (Bottom up Broadband) optical fiber model works for rural areas (farms and isolated houses).

This kind of deployments are essentially aerial. On the contrary, the area of the third iteration is an urban area (mostly detached houses with seldom apartment buildings), so in this deployment the wiring will be done mostly using already existing ducts owned by the local government. The terms for their usage have already been established and the agreements signed.

4.2.2. The PoP

Gurb has its own PoP fully operational. The POP is placed in a barrack placed in the garden of a member of guifi.net, which also hosts a data center where the guifi.net partners can collocate their hardware. Figure 11 shows the main rack.

This POP has been operative since 2010. This year the power supply system has been improved by adding a back-up power supply, and also the electronic equipment has been significantly extended to accommodate the necessities deriving from Gurb's OF pilot deployment and other connections.

At the roof of the barrack there are lots of antennas connecting to some other nodes. This nodes can find a gateway to the internet in this spot.

In the rack we can find an the OLT, that multiplexes and routes the traffic going in and out from Gurb. This device accepts also the ethernet cables coming from the routers integrated in the antennas.

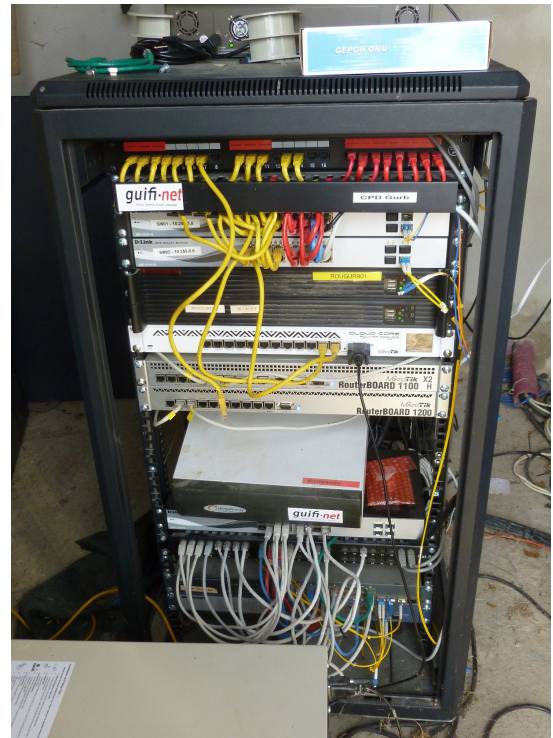


Figure 11: The Gurb's PoP multi-purpose rack



Figure 12: Multiple antennas in the PoP supernode.

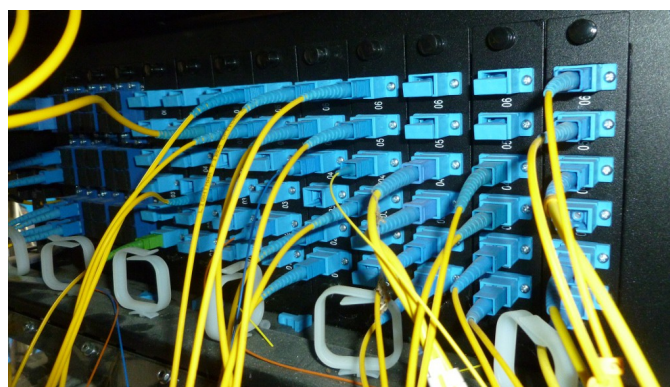


Figure 13: The OLT managing all the fibers and ethernet wires.

4.2.3 Wire installation

We find the cables hanged beside the telephone ones all along the track outside the nucleus of Gurb. This aerial deployment crosses several crop fields, which owners authorized and collaborated to install. The buried part of the line starts in a street which was recently improved. The collaboration of the Gurb council has been essential to achieve this, as it isn't easy to get the permits over the public street.

In the aerial deployment part, we can see from pole to pole, a black box with a ring of bunched cable. This ring of cable is left there so that the installation and reparations can be done down to the floor. Inside the black boxes some fibers are separated to new branch of distribution, without any optical treatment. See Figure 14.

In Figure 15 we see the same bifurcation but in underground context.



Figure 14: A bifurcation of the cable from the PoP. One goes to the urban area of Gurb, and the other to a residential area.



Figure 15: The cable follow the street advancing underground. One bunch of fibers turn to the left, the other bunch continues straight.

4.2.4 The splitters

Splitters are fundamental devices in optical networks. They allow us to carry all the traffic in one single fiber and distribute the channels with many fibers later.

Active splitters demultiplex the signal and deliver each fiber only the corresponding channels. As for the uplink, it multiplexes again. Active splitters are expensive and need to be powered. However, they don't introduce any attenuation.

Passive splitters don't demultiplex the signal, but copies it to every other fiber. At the endpoint, the ONU is supposed to keep only its channel. The uplink is possible using TDMA for accessing the shared resource, the fiber that carries all the traffic. Thus, the splitter sums up all the uplinks and there appear no interferences. The passive solution is cheaper and easier to deploy. When possible, it is better to use them. The usage of this devices converts the network in a passive optical network (PON).

In Figure 16, there is only one fiber that gets to the PoP. From on hole of the right side, this one fiber and some others that branch before arriving to the PoP, get to the mirror in the left side. The actual device is the rectangular metallic piece in the left side. Once reflected, the information travels to the branching fibers and come back to the right part of the box. From there, they go to the PoP direction or to Vic direction, choosing one cable (hole) or the other.

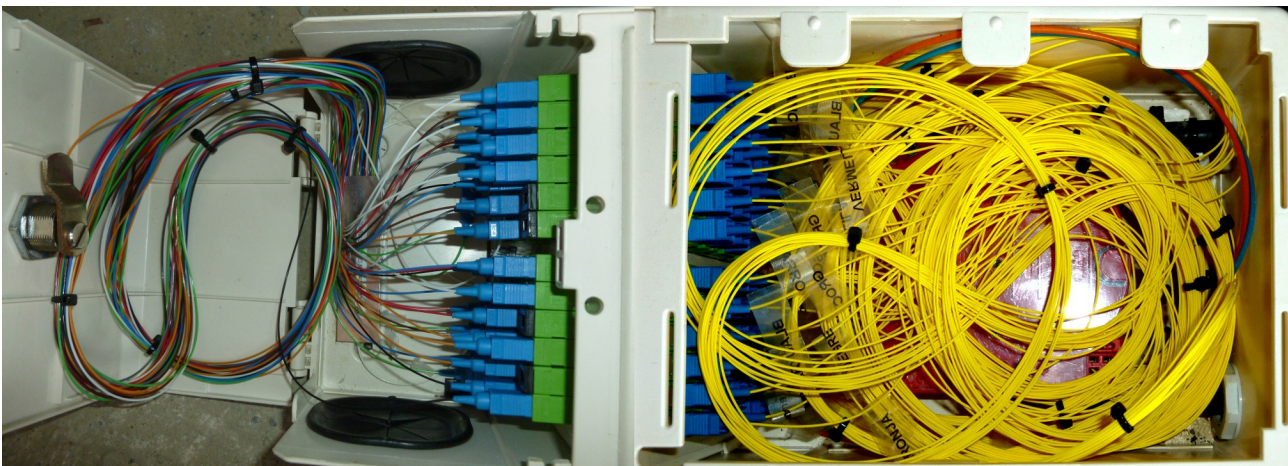


Figure 16: A passive splitter.

5. Gateway to the Internet

We have seen everything from the PoP's down, but until now it hasn't made clear who pays what in order to access the Internet. There are two solutions, which we describe below.

5.1 Federated proxies

In this method, the provider is a user with a supernode that shares its own connection with the other users. In order to take profit of it, it is needed to have a registered node working in the guifi.net webpage. Once obtained the username and password, you will be given the IP of a proxy. Logging into that proxy with the identity provided, the access to the internet is achieved.

This solution is managed collectively and the cost of the connection is payed by the node where the proxy is allocated. Moreover, everyone connected to the proxy will appear to have the same IP that the proxy.

5.2 VPN tunneling

The VPN is a technology that allows a user from a network appear to be connected to another network. It is called “tunneling”, as every packet is sent to the internet, passing through “a tunnel” across the network until it reaches the target local network. Following this logic, if that local network has a gateway to the internet, once a user is connected to that network, has also access to the internet.

There are projects of creating consumer cooperatives for hiring a broadband connection and share it with all the associates. However, the ones who use this solution by now are the so-called guifi.net internet providers. These companies do hire a broadband connection and they adjudicate IP to the users, which will share the total bandwidth of the operator.

Nowadays there are four providers in Osona (Vic, Gurb and all the region), but there are two who gather most of the users: Gaufix and Gurbtec. They both offer access through optical fiber and through the WiFi mesh. Their prices are frightening the big ISP, as they see how the people of Osona is leaving the precarious connections and upgrading to broadband over guifi.net. Their prices are:

- Wifi: symmetric 6Mbps → 10€/month
- Fiber: symmetric 1Gbps → 20€/month

However, the nominal rate of the fiber is around 400Mbps, as usual as with classic ISP. Since then, Telefónica has speeded up its fiber deploying and tries to be competitive there.

5.3 Sharing the connection expenses

In Osona there are around 2000 clients of the guifi.net internet providers. They grow every year, as the offer is very competitive. This means that all these people rely on a collective distributed network, and that connect everyday to the internet using this infrastructure. Other people may use other techniques, as the before mentioned, in order to connect to the internet, but this one is for sure the strongest one.

But how do these providers connect the user to the world? Once we know who offers access to the Internet, we need to know how do they get it. And this is curious, because all the expenses are shared between the providers and the Foundation. The supernodes are maintained also by the providers, as they make profit of these infrastructure.

The fiber network in Gurb and Vic end up in a so-called PoP, which is a place with interconnection to the internet. From that place, two fibers (one for backup) go to a point of connection of Xarxa Oberta de Catalunya, who guifi.net hires a channel to. This channel arrives to Barcelona, where there are the serious business. There, they pays for Telvent for a climated, controlled and backed-up installation of racks and interconnections. It is here were guifi.net connects to the CATNIX to peer with other ISP, and to Cogent, a wholesaler of peering with world-wide ISP. Guifi.net also pays to Cogent for its services. This is where the circle is closed.

In summary, it has been demonstrated that the big and centralist ISP aren't so necessary as they seem, and that when the people join to solve a problem, is able to achieve it so well that even is able to threaten the monopoly of big ISP in certain regions. We will see if in a future guifi.net grows enough to build a country-wide, reliable, open and free network controlled and build by the end users.

5. Acknowledgments

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