

Research article

A new community business model for a free, open, and neutral network: Considering the wireless to fiber transition

Aleix Llusà Serra ^{*}, Francisco del Àguila López, Jordi Bonet Dalmau, Xavier Moncunill-Geniz

Universitat Politècnica de Catalunya (UPC) Department of Mining, Industrial and ICT Engineering (EMIT), Av. Bases de Manresa 61–73, 08242 Manresa, Catalonia, Spain

ARTICLE INFO

Keywords:

Free, Open and neutral network
Fiber/wireless network
Free software
Ownership and business models
Tragedy of the anticommons

ABSTRACT

Free, open, and neutral network (FONN) is an alternative to the prevailing proprietary ISP networks on the Internet. From the FONN manifesto, we conceive two main goals: to give freedom to users and to cooperate in building and maintaining the FONN infrastructure. However, the manifesto avoids talking about the business model of this infrastructure and neglects to give the appropriate role to each member of the community in building and maintaining this infrastructure. Moreover, current research misplaces FONN's cooperation in the avoidance of the tragedy of the commons and also overlooks ownership. The move from wireless to fiber has amplified the consequences of not considering ownership or member roles. In order to fill the previous gaps, in this article we will first relate the objectives of this manifesto to the field of free software. Next we will argue that FONN's cooperation should be placed in the avoidance of the tragedy of the anticommons. Inspired by free software we define a new business model for FONN besides discussing different ownership licenses. Furthermore, we state the roles of members and rigorously model the economic flow of construction and maintenance costs. The main implication of the proposed business model is that future FONNs will avoid the economic and organizational collapse of some current FONN communities, mainly because funding cannot be based solely on crowdfunding or volunteering. Yet, as an overall benefit, FONN avoids the duplication of infrastructure. This new business model has been used successfully in the fiber deployment of a FONN section.

1. Introduction

Internet is a global system of interconnected computer networks; the network of networks. Some questions that have arisen are: who owns this big infrastructure, where is the governance, and how is guaranteed an equal, open, non-discriminatory, and non filtered access.

Trying to resolve these questions free, open, and neutral network (FONN) were defined, similarly as free software was defined regarding users' freedom, where it must be remembered that “free” means “libre” [1]. The fundamental principles of the FONN are guaranteed by a manifesto: FONN manifesto [2]. Note that these FONN manifesto principles date from 2009; in our opinion their redaction could be improved and they could also include references to other related concepts such as the open and neutral Internet EU Regulation 2015/2120 [3]. However, as stated in [2], these fundamental principles are the following:

^{*} Corresponding author.

E-mail addresses: aleix.llusa@upc.edu (A. Llusà Serra), fd.aguila@upc.edu (F. del Àguila López), jordi.bonet@upc.edu (J. Bonet Dalmau), xavier.moncunill@upc.edu (X. Moncunill-Geniz).

<https://doi.org/10.1016/j.iot.2024.101157>

Received 23 January 2024; Received in revised form 1 March 2024; Accepted 6 March 2024

Available online 7 March 2024

2542-6605/© 2024 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

- It is open because it is universally open to the participation of everybody without any kind of exclusion nor discrimination, and because it is always described how it works and its components, enabling everyone to improve it [2].
- It is free because everybody can use it for whatever purpose and enjoy it as foreseen in the freedoms of the “General principles”, independently of his network participation degree [2].
- It is neutral because the network is independent of the contents, it does not influence them and they can freely circulate; the users can access and produce contents independently to their financial capacity or their social condition [2].

FONN were born aiming at the users’ Internet freedom but the precipitating cause was that ISPs were not interested in building infrastructure in rural areas nor sparsely populated areas. They also were born as community networks, without governance, and focusing on the technological approach of wireless broadband mesh networks.¹ However, FONN have evolved to become professional networks where the main objective is to guarantee the users’ freedom. Furthermore, in the broader economic situation, they have positioned in the necessity of cooperating and trying not to duplicate network infrastructure: in this paper we will analyze this as the avoidance of the tragedy of anticommons.

To achieve all these challenges, wireless broadband mesh networks do not provide enough quality. Therefore FONN have been redirected to fiber network technology. FONN have also evolved from a best-effort network perspective to a professional one, that is to say to a network with also professional ISPs offering high quality services. However the FONN manifesto is still written with the original perspective of community wireless broadband mesh network where there is no need for achieving quality nor discussing ownership and interactions between members. We find that the original FONN manifesto could be maintained — as the basis for enumerating FONN freedoms — but then there is a need for writing a business model for FONN that enables to manage these new challenges. In this paper we focus on this FONN business model.

One of the largest FONN and also the first to set the FONN manifesto with a global perspective [4] is *guifi.net* [5]. In this paper we use *guifi.net* as a real context where FONN are in a working and professional state. There are other similar wireless community network projects [6–8] which were born in parallel to *guifi.net*, however they have not evolved from amateur projects and they only aim at mesh FONN. In this particular mesh amateur case there is no need for a business model as it is assumed that each user build and maintains his node and it is also assumed that there are enough nodes to prevent collapsing when a user decides to quit the network. We see this particular case as a subset of FONN limited by being non-commercial, amateur, and self-managed. Therefore in this paper we discard them as a generic context for FONN, although it must be noted that they fit perfectly as a subset in our resulting model. Another community network projects have evolved to non-profit networks [9], however they explicitly state that are not intended for replacing the main Internet connection but only for passers-by connecting for a limited time.

From a broader point of view, the term *community networks* [4,10] is used in the sense of deploying infrastructure for rural areas, sparsely populated areas, underdeveloped countries... in order to eliminate the unequal access to Internet, which is also called *the digital divide*. FONN can also be used in this community networks context and fit also as a subset in our resulting model, and we show that for the case in areas that are financially unattractive for mainstream ISPs. However, the viability in some other cases like underdeveloped countries should be studied further.

From another point of view, a recent Europe’s survey shows a “large agreement of the importance of ensuring Europe takes a leading role on the digital transformation, protecting its sovereignty and contributing to the EU environmental and sustainability objectives” [11]. It also shows that while the traffic and high-capacity networks requirements are increasing, the telecoms sector has a weak financial health and a lack of return on investment for the private sector as the main barrier to deploying fiber. This is related to the fair contribution discussion, also called fair share initiative, that might make the large traffic generators contribute to ISP infrastructures. However, our approach in this paper is to focus the fair share discussion to the final consumers/citizens: that is to say that, whatever the fair share final solution, citizens will surely end up funding these additional investment needs of the sector. Therefore in our business model citizens mainly fund and own indirectly the infrastructure deployment and maintenance, whereas ISP or large traffic generators are welcome to contribute as investors in order to accelerate the necessary improvements.

Consequently, in this paper we try to be as generic as possible for FONN and not focus on a particular case. We see FONN as being able to achieve the same quality as other private ISP networks, in addition including a sustainability challenge of not duplicating network infrastructure. Furthermore, this point of view does not exclude the particular cases for best-effort amateur subnetworks nor for digital divide social necessities. We would like to remark that this is the same point of view as in free software [1] where: “a program licensed with commercial restrictions does not qualify as free software”, “free software is a matter of liberty not price nor meaning gratis”, and reducing digital divide is not in the main focus.

Summarizing, the FONN manifesto has been already defined and is adequate —despite minor improvements— as the basis for enumerating FONN freedoms. However, since FONN needs not only to be based on mesh topology and it is interested in having professional ISPs, the FONN business model needs to be redefined. In this paper we define a new FONN business model addressing the following concepts:

- Member roles
- Ownership and FONN license
- Business model relationships and user-centered fixed fees

We take into account the following FONN objectives, by order of priority:

¹ A mesh network is a topology in which the infrastructure nodes talk many to many cooperating in order to route packages.

1. Respects users' freedom and community
2. Cooperate and not duplicate network infrastructure
3. Allow commercial use and paid professional support

This paper is structured as follows. In Section 2 we present some ideas from the free software area that can be considered later for FONN. In Section 3 we move the FONN context from the tragedy of the commons to that of the anticommons. In Section 4 we briefly present the history of *guifi.net* FONN and discuss existing research. In Section 5 we define the new FONN business model. In Section 6 we study a particular case where we have applied the new FONN business model. We conclude the paper in Section 7.

2. Inspired by free software

The FONN manifesto —rooting freedoms for network users— is somehow parallel to the free software manifesto [1] —rooting four freedoms for software users. Note that we stand for the term *free (libre) software* as stated in [1], where others might use the term *free/libre open source software* or simply *FOSS* or *FLOSS*. It is difficult to establish similarities between free software and FONN as network is operated like a transport service whereas software is executed from a code like a product. Furthermore, software can be easily copied, distributed, executed, changed, stored and so on whereas network is a physical good.

However, another two remarks on the free software movement have attracted our attention for our new FONN business model purpose.

On the one hand, besides the free software four freedoms the community has also felt the necessity for exploring free software business models [12,13]. In short, it is not sufficient to build the software only from volunteers and crowdfunding. As stated in the manifesto [1] “Commercial development of free software is no longer unusual; such free commercial software is very important. Paid, professional support for free software fills an important need”. This has also lead the free software community to the necessity of issuing a contributor license agreement (CLA) to those who contribute to the code. CLA clearly state to who belong the intellectual property rights of each contribution, that is the ownership of copyright. A CLA is especially important for copyleft free software and there are organizations that claim the user to transfer them the contribution full ownership, for instance in [14].

On the other hand, there have been a proliferation of different free software licenses in order to accomplish different targets. Note that not all of these licenses are considered fully free software [1]. Even though this concept cannot be directly applied to FONN, it has served as a basis for the concept of FONN license we define in Section 5.3.

3. Commons versus anticommons

The FONN problem context has been previously located in the scarcity of natural resources and the tragedy of the commons [15–17]. However, we suggest to reconsider it in favor of the tragedy of the anticommons [18,19]; the anticommons problem in which resources are inefficiently underutilized rather than overutilized.

First, the tragedy of the commons would mean that some ISPs or some user misused the FONN, such as filling all the bandwidth. From a technological point of view, this would be rare as when a lot of users require communication their bandwidth is divided for each. That is, all receive the same bandwidth degradation; so no one can rule above the others.

Second, considering the fiber networks as scarce is odd for ISPs. They have duplicated fiber networks in cities, almost each private ISP wants to have its private network. Moreover, some connections between cities have been also duplicated. Their feeling is that fiber is a cheap resource in densely populated areas and they get quick returns on investment. This is also concluded in [16] by assuming fiber “becomes a non-rivalrous asset (zero marginal production costs) due to its virtually unlimited bandwidth”.

Consequently, the context should be the one defined by the tragedy of the anticommons. The FONN tries to avoid the problems that result from not sharing all those private networks: fiber duplicity, underuse of each private infrastructure, high fixed costs, unaffordable for small ISPs... If there had not been this tragedy of anticommons by not duplicating fiber networks in cities, now for sure there would be more fiber coverage in rural areas. So FONN needs to persuade private ISPs and prove that by cooperating they will earn more benefits. This is also our main motivation to define the new business model in Section 5 more user-centered instead of ISP-centered.

4. A reference FONN: *guifi.net*

Guifi.net was born in 2004 in Osona, Catalonia, as a community-owned network communications project. It aimed at the users' Internet freedom but the precipitating cause was that ISPs were not interested in building infrastructure in rural areas, however *guifi.net* achieved to build a shared wireless broadband network infrastructure where all the members received and at the same time transmitted the signal to other members. Since then the project has evolved by expanding —mainly in Catalonia and Basque Country— and by including fiber optics networks. Furthermore, nowadays the governance of this community-owned network is made by a foundation, *Fundació guiifi.net* [20], and the fundamental principles of the community-owned network are guaranteed by the FONN manifesto [2].

Next we summarize in three stages some historical evolution of *guiifi.net*. More detailed information can be found in [5,16].

Initially the target for *guiifi.net* was to reach rural areas lacking Internet access, but it also undertook the goal for promoting a FONN everywhere. This initiated what was called *Commons movement* [15,17] somehow inspired by the free software movement.

We perceive that at this first stage the movement was thinking in building a mesh wireless broadband network. This historical orientation can still be seen in the current FONN manifesto as instance “it is formed by assets that are the infrastructures that

integrate their participants” [2, IV About Proprietorship and Participants]. Moreover, this network was built and managed by volunteers.

At a second stage, when the infrastructure increased, a mesh network unsuccessfully accomplished stability requirements and acceptable bandwidth. Therefore, the network topology turned to a hybrid star/redundant tree² wireless broadband network. Firstly it was financed by crowdfunding. Later, professional ISPs appeared to offer professional network services to the users —note that this is allowed and encouraged by the FONN manifesto. So it became a mixed network of volunteers and professionals, the latter financing nodes by business methods such as bank loans. Fundació *guiifi.net* defined an economic compensation system to put together these new realities as, in our opinion, the FONN manifesto only works for a mesh topology, economically speaking.

At a third stage, the infrastructure is deprecating wireless broadband network in favor for fiber passive optical network.³ At this stage the movement has increased the will for sharing network infrastructure and dislikes not FONN ISPs who duplicate fiber cables. However, at this stage some ISPs are quitting from FONN induced by the fiber fever short economic returns. This poses a serious problem as some ISPs own the major part of the FONN and when they quit they retain their ownership part of the network, which becomes private.

We must notice that they are able to quit because *guiifi.net* has never addressed the problem of the ownership for the common infrastructure. Needless to say that then there is no possibility to guarantee the FONN freedoms for users that get trapped inside these private networks. Furthermore, we must also notice that the Fundació *guiifi.net* economic compensation system does not fit in this new environment of fiber, professionals, and investments. We address these concepts in Section.

4.1. Discussion of previous research

First of all, as *guiifi.net* complies the FONN manifesto all the information is public at [5]. Similarly, as it is governed by a foundation the legislation coerces the Fundació *guiifi.net* to publish its economical activity at [20]. However, all this information is not sufficient for understanding deeply the FONN concepts as there are theoretical backgrounds that must be scientifically analyzed. Next, we summarize some of these analysis.

In [15,17] there is a complete analysis for the members, the governance, the infrastructure, and the software tools for *guiifi.net*. In [16] it is defined the economic compensation system for the last mile in the network. In [21] there are similar cases to *guiifi.net* and FONN and there is a sound definition for the economic compensation system for the services that Fundació *guiifi.net* provides to FONN ISPs, which the main one is the Internet external traffic.

Our new business model defined in Section 5.5 means to be a replacement for this economic compensation system. We summarize the previous model drawbacks in three concepts: not attending ownership, variable costs ISP centered, and not clearly stating members’ roles.

First, the economic compensation system did not work at long-term owing to the fact it did not take into account ownership of the FONN. The previous model assumed nothing about ownership [15–17] so it should be assumed that who built it owns it. However the model points that, as FONN uses these infrastructures, they must be money compensated. This compensation model rooted on users with an ISP paying a fee to foundation and then foundation returning back compensations. These money compensations must be used for building new FONN not for returning the already built investment. So the original FONN remains owned by the ISPs which at long term poses problems, such as that the owner can quit FONN and the users that have payed the fee are abandoned without network. Moreover, the money given was considered an actual *compensation* so who is the owner of the new network built was also not clear by the model. Therefore, at long term, some few ISPs owned the majority of the FONN and have decided to quit, furthermore one of their main reason argued was that they had given their original network for free without any return. From the foundation point of view the compensation model aimed to be this return, however the big misconception between foundation and ISPs is that both think that they are the only true owners for the FONN.

Second, the economic compensation system was centered to ISPs, the fees were variable depending on the traffic of each ISP [21]. Furthermore, “a participant pays more when not cooperating with anyone else” [21], depending on the contribution of infrastructure there are “type A full commitment”, “type B partial commitment”, or “type C opportunistic” [15]. We find this classification A, B, C is against the FONN manifesto where commercial uses are granted and liberalized besides that Fundació *guiifi.net* must not assess what professionals do in their private business. Also we have not found any similar concept in the free software movement, where there is a separation of concerns between contributing to and using a software. Using the software may have a price, however it is independent of the contributions made. Contributions are solely at the interest of the contributor, maybe for a salary, but for sure he earns an unvaluable know-how and a reputation inside the community. Moreover, in free software it is not compulsory to share your private changes; so you are not charged a fine if you do use a software but you do not contribute. However, unlike free software FONN is more like a transport service so costs must be achieved. Considering fiber networks have virtually unlimited bandwidth, as previously stated, we feel more natural that most of the costs are achieved equally by users from a fixed fee. Anyway, the [21] variable model could be applied for extra services that Fundació *guiifi.net* offers to ISPs, such as external traffic, legal services, or insurances.

Third, the FONN members were classified in roles depending on their behavior, interests, and cooperation [15–17]. That is, they were classified whether they had commercial, community-owned, non-profit, or privately interests and as said they received

² A star network is a topology in which a node only talks to a central hub node. These central hub nodes are interconnected in a tree fashion with some ring connections for redundancy purposes.

³ Passive optical network is a fiber technology whose topology is point to multipoint.

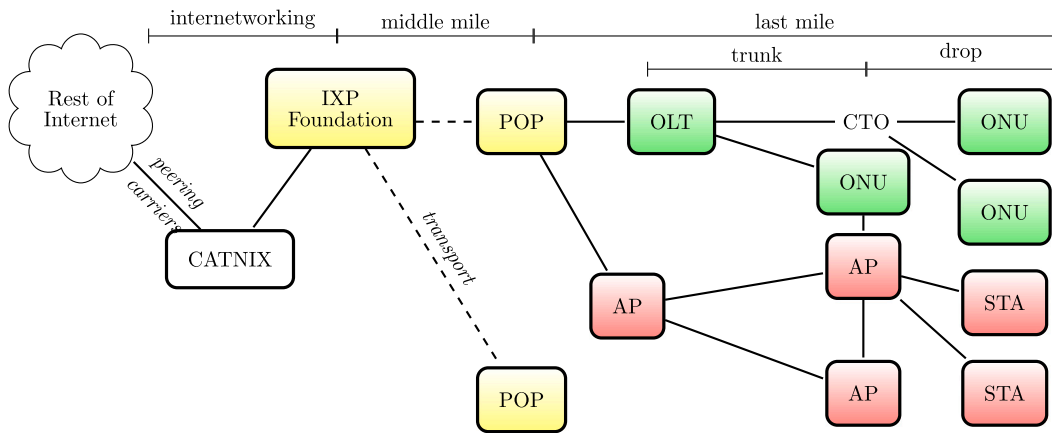


Fig. 1. *guifi.net* topology with PON fiber and wireless broadband.

different prices owing to these roles. Note that, in addition to volunteers, [16] is interested in attracting professionals in order FONN becomes stable and comparable to private networks. However then members' roles should be distinguished clearly depending on the actions they take on the FONN and it does not matter what is their target as FONN must grant commercial rights and is free for uses. The only restriction could be some like free software copyleft, that is that FONN already deployed do no converts back to private. Unfortunately this ownership point of view has not been assumed for FONN, as instance [15] assume "they [investors] keep the ownership of hardware they have contributed and the right to withdraw".

5. The new business model

We define the new FONN business model structured in five parts. First, we clarify the technological network concepts involved. Second, we define user-centered fees to meet the costs. Third, we define the new concept of FONN license. Fourth, we define the member roles, and fifth, we define their relationships and the ownership flow as the core for the business model.

Finally, we exemplify the business model with a practical case that shows an expected evolution of ownership flow and FONN license along time.

5.1. The network topology

The FONN is all the Internet subnetworks worldwide under the FONN manifesto, the agreement that enunciates the four freedoms and other requirements for FONN. *guifi.net* is actually the largest known FONN [5] and Fundació *guifi.net* is the foundation that governs *guifi.net* [20]. The *guifi.net* topology can be divided into three main parts [21], which are depicted in Fig. 1.

At the top there is internetworking, the network operation centre located in an internet exchange point (IXP). An IXP is the neutral location where the external Internet traffic is exchanged through peering with other ISPs or through network service providers (*carriers*). CATNIX is nowadays the only IXP for *guifi.net*.

At the middle there is middle mile that connects the internetworking to last mile POPs', nowadays it is deployed over third parties so it is also called *regional transport*, where POP is each of the regional local access point of presence. Perhaps some day the last mile will grow enough to extend over regions and then to not depend on third parties for middle mile.

At the bottom there is last mile, the access network that connects POPs to final users. From the physical point of view, the *guifi.net* network mainly is based on fiber —fiber optic telecommunications usually on point to point or PON architectures— or wireless broadband —high-speed fixed wireless networking usually on unlicensed bands. However other technology can be also used, for example LoRa.

PON, passive optical network fiber technology, starts at an OLT, optical line terminal the service provider endpoint, and ends in the ONUs, optical network unit the final device for users; in between is distributed in splitters and in CTOs, core fiber optic terminal boxes. We call trunk from OLT to CTO and drop from CTO to ONU.

Wireless broadband has a hybrid star/redundant tree network topology in which a STA, the station final device for users, only talks to a AP, the access point as a hub routing to other APs interconnected in a tree fashion with some ring connections for redundancy purposes.

For internal network identification each device (OLT, ONU, STA, AP) is assigned an IP 10.X, a private IP in the 10.0.0.0/8 range. All the network topology including these IP 10.X must be documented, *guifi.net* has a web framework for managing this network documentation [5]. Note that as all ONUs are documented, the exact number of users is always known and is also auditable. Inside this internal network there could also be internal Internet services however as there are only few of them, such as Domain Name Service, we can conclude that nowadays *guifi.net* is mainly a network for providing global Internet services access.

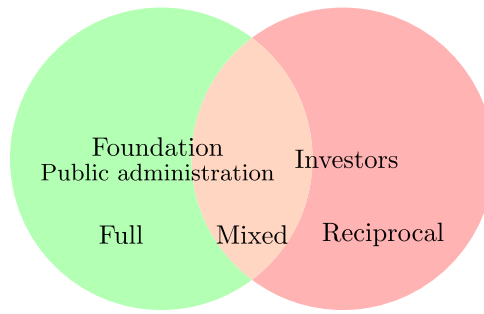


Fig. 2. FONN licenses.

5.2. User-centered fixed fees

A FONN must be built, maintained, and operated, which has costs. These costs must be covered by members. Our new business model focuses on users fees, a fixed price that each user must satisfy to cover all FONN costs. We center fees in users as anyway they would finance these costs and after all FONN is about their freedoms.

There are two categories of fees: CAPEX and OPEX. In addition there are the internet services costs, however these are decided solely by providers which we explain in Section 5.4.3.

We call CAPEX to the building infrastructure starting fee. We call OPEX to the maintaining and operating monthly fee. OPEX covers all the costs in maintenance (repair a broken fiber or replace a broken device), in operations (monitoring, changing device settings, electricity, internetworking presence, taxes), and in administrative expenses (insurances, legal advice, FONN marketing). Currently IXP traffic and POPs's regional transport costs are paid by provider's internet services but in future they could also be included in OPEX.

To set a reference purpose, we write the current *guiifi.net* fees values. For CAPEX *guiifi.net* has 1500€ for fiber and 300€ for wireless broadband, or alternatively it can be of 17€/month when the initial investment has covered all costs. For OPEX fee *guiifi.net* has 6€/month for fiber and 4€/month for wireless broadband. However the particular values for fees are not so important, *guiifi.net* computed them as an estimate of average costs. The key point resides is in that these fees may be changed any time by Fundació *guiifi.net* in agreement with *guiifi.net* members in what is called *network council*. Obviously the particular values depend on whether the fees are enough to meet the total costs. As instance the 1500€ CAPEX value has proved to be a correct average value for the Fundació *guiifi.net* scenario. Note that FONN is deployed also in rural areas and tries to connect even remote farmhouses, if the FONN main purpose was only cities then the CAPEX value would be lower. And as the network gets bigger, this value is expected to decrease.

5.3. FONN license

We define the new concept of FONN license to distinguish three types of license regarding FONN ownership: full, mixed, and reciprocal. We define this new concept inspired by the concept of diverse licensing in free software. All FONN licenses grant rights for commercial use, the same is stated by free software manifesto "a free program must be available for commercial use" [1].

The FONN can be owned by foundation, public administrations, and investors. Owing to these possibilities we distinguish the tree FONN licenses, which is depicted in Fig. 2. All the FONN licenses must respect the FONN manifesto:

- Full is when the FONN owners are only foundations or public administrations
- Reciprocal is when the FONN owners are only investors and they establish reciprocity with the FONN manifesto. It considers exceptional cases, such as other community networks already built but wishing to cooperate.
- Mixed is when the FONN owners are foundations, public administrations, and investors

In order to apply different FONN licenses the network cannot be seen as a whole and it must be divided into FONN sections. These sections should not be too small, so let us assume that there is one FONN section for each POP and those can also be divided into subsections for each bigger trunks. Then FONN licenses apply to each FONN section.

Each FONN section will evolve at his own pace from one FONN license to an another, depending on how ownership flows as we define in Section 5.5. FONN must promote the fulls ones, or also mixeds as in the long term they should converge to fulls. In this context reciprocals is an attempt of flexibility to attend commercial providers needs. However, there is one requirement: a full or a mixed cannot transform back to reciprocal. This requirement is similar to the copyleft concept on free software.

It can be remarked that a biggest difference from mixed to reciprocal is that at mixed foundation makes the deployment and is the legal title holder, so foundation manages the maintenance and operations costs from OPEX fees. On the contrary, investors must solely respond for reciprocals, however then they can set a rental fee such as a bit-stream access.

Finally note that full, mixed, and reciprocal are always under the FONN manifesto. In a similar way as proprietary software, we say that private network is all that which is not FONN. We should point that currently in *guiifi.net* there are still private network sections such as IXP traffic *carriers* and POPs's regional transport besides others.

5.4. Member roles

The members are all the people around the FONN. Each member has a role inside the FONN which must be clearly and independently stated because each one must sign an agreement with his rights and obligations, like the free software CLA (see Section 2). This independence in roles does not prevent that a member plays more than one role, then he simply must sign an agreement for each role, however he should be aware whichever role is playing in each case and try not to mix concepts.

Next we define the rights and obligations for each role. They are defined in a descriptive model way, then they should be assembled in legal agreements by foundation. The possible member roles are: builder, maintainer, provider, user, foundation, public administration, investor, and promoter.

5.4.1. Builder

A builder deploys new trunks, drops, OLTs, ONUs, APs... and is being paid for these services. Builder's rights and obligations are:

- Documents the new network to foundation
- Invoices the services and the materials stating the concept sold or deployed infrastructure
- Invoices to:
 - Foundation: in case of full
 - Investors: in case of mixed. Invoice copy to foundation.

5.4.2. Maintainer

A maintainer repairs, changes, maintains and operates the network. He operates the network by changing router settings and so on. He repairs or changes broken material, that is a similar role as a builder but only for previously built network. He can be in charge of a last mile to monitor and prevent malfunctions.

- Documents any network change to foundation
- Invoices to foundation stating the concept repaired or changed infrastructure. There are three options:
 - By the particular cost of each maintenance, foundation can agree a price list.
 - By a monthly service contract. For example the price can be based on users quantity or on kilometers of fiber.
 - As a volunteer. Then foundation bills the material. The compromise is as a volunteer, no professional responsibilities can be demanded.
- The initial investor can decide the first maintainer, but foundation can change it if it does not work
- A provider can ask for being the maintainer for the drop of his users, as he may want to give his corporate image inside the user's home.

5.4.3. Provider

A provider is an ISP inside the FONN who offers internet services to users. A internet service is whichever product a provider offers to an user at a monthly rate. In this sense, providers use superficially FONN as a transport network.

- Documents to foundation each user it has.
- Informs the user that he is serving under the FONN and subject to foundation.
- Charges CAPEX and OPEX to user and transfers them to foundation. In case of more than one provider per user, foundation decides which one charges the fees, then this role could be called *operator*.
- Configures the ONU or the STA and assigns an IP 10.X.
- Decides the internet service price at his will. Foundation cannot require nor decide anything about these internet services.
- Should not charge for simple transport as it is already included in FONN fees.

Some internet service examples may be: Internet access service, public IP for Internet, cable television, IP telephony or VoIP, data backup, extra quality over FONN (such as network reliability between STAs)...

5.4.4. User

A user uses the FONN as a communications network, respecting the FONN manifesto. He can deploy over the FONN whichever services he wants, also he can be a customer of a provider.

- Pays CAPEX and OPEX to foundation, may be through a provider.
- Each user should be one living or working space, multiple users should not aggregate CAPEX and OPEX fees.
- In case CAPEX fee is not enough for the initial costs the user must pay the rest, for which he may become an investor

5.4.5. Foundation

Foundation is the nonprofit governance for the FONN.

- Manages the network map and the IP 10.X assignments.
- Provides the agreements to members according to the roles
- Defines the CAPEX and OPEX fees by consensus with other members
- Promotes the FONN worldwide, promotes the collaboration from public administration and promotes for CAPEX donation
- Bears and holds the legal rights for the FONN:
 - States the network deployment to the competent authority
 - Declares the use of third party infrastructures and pays rental costs or taxes
 - Meets the compensations for any damages caused by FONN
 - Defends legally the members against FONN threats
- Pays from OPEX all the services needed for FONN such as operations, rentals, taxes, promotion, or legal services. This also includes covering from OPEX the foundation internal costs.
- Offers extra services to providers as a joint venture in order to gain scale efficiencies. The main extra service is the IXP transit. Others examples are colocation at internetworking, public IP rental, or legal assistance.

5.4.6. Public administration

A public administration is an investor that can keep the network ownership alike foundation. Has the same obligations as an investor with the following cases:

- Must be public government or public corporations, which includes local administration, public universities and so on.
- Decides the FONN license
 - Full: keeps the ownership
 - Mixed: foundation will buy ownership when there is CAPEX available

5.4.7. Investor

An investor purchases new FONN deployments and expects the return of all the investment plus a profit but with total capital risk. Multiple investors may join to deploy new FONN.

- Purchases new network to a builder. The capital of this operation is registered by foundation plus an expected profit. This capital plus profit indicates an ownership percentage over the FONN; it is of 100% in case of new FONN.
- The profit is decided by foundation. It could be an annual interest rate with a limit or a fixed interest quantity, such as the double of the cost.
- Has total risk of loss, there is no guarantee of capital nor profit return. However, the investor keeps the ownership percentage while there is no return.
- Must exchange the ownership percentage at the capital plus profit agreed whenever foundation wants to acquire the investment from CAPEX fees. When the ownership percentage reaches 0% he loses the investor role.
- Decides the FONN license:
 - Full: donates ownership to foundation
 - Mixed: initially has an ownership percentage that foundation will acquire when there is CAPEX availability. During this time foundation manages the maintenance and operations costs from OPEX fees, consequently the investor has no dividends nor rental income.
 - Reciprocal: has the full ownership and manages the maintenance and operations costs from his own budget, consequently he can set a rental fee such as a bit-stream access. However a reciprocal can only be deployed to another trunk that also is a reciprocal.

5.4.8. Promoter

A promoter manages the CAPEX surplus he has achieved by persuading users or investors. Usually this role is associated to providers, as are the ones that persuade users to come to FONN and pay the CAPEX.

- When CAPEX is enough for building a drop and the FONN license is full, then foundation assigns these surplus to the promoter.
- Has a CAPEX deposit which is a register where foundation holds how much CAPEX surplus can spend each promoter
- Only decides about the CAPEX surplus, foundation is the owner of this surplus and also will have the ownership for the new FONN deployed with them.
- Points foundation how must spend the CAPEX surplus:
 - Build new FONN and where
 - Purchase existing mixed in other FONN regions

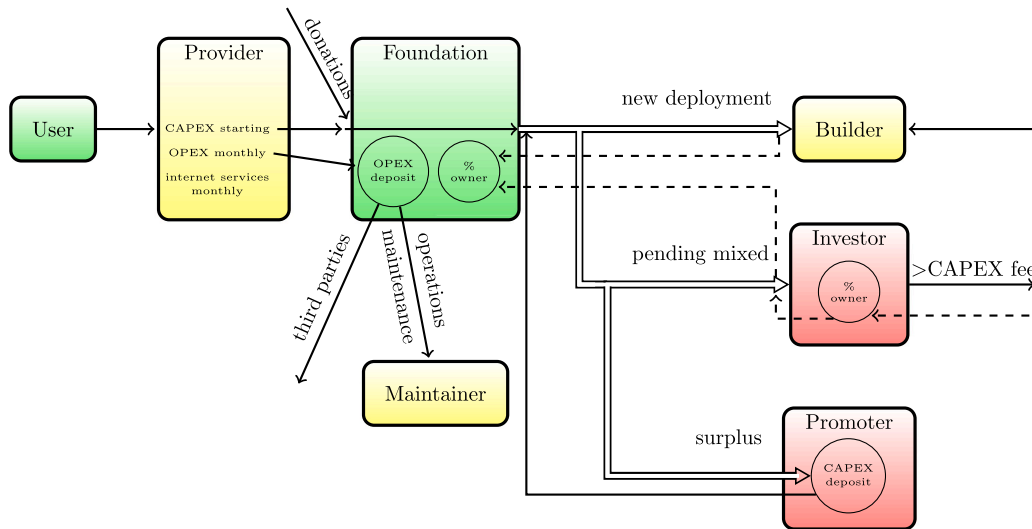


Fig. 3. Business model relationships with ownership (dashed), CAPEX and OPEX flow.

5.5. Relationships and flows

The core of the business model is in the members relationships, which are shown in Fig. 3, including the ownership, CAPEX, and OPEX flow. Members blocks appear with different color depending on their main role on FONN: just being a service provider being paid (provider, maintainer, builder), investing money (investor, promoter), or governing and using (foundation, user).

The deployment of a new trunk or a new drop starts when a user wants FONN internet services, usually this is promoted by a provider. Then the user pays to provider an invoice that includes for first time the starting CAPEX fee and since then the monthly OPEX and internet service fees. The provider transfers CAPEX and OPEX to foundation on behalf of the user. The provider earns the internet service fee which refers to whichever products he is offering to user, at the very least it might be the Internet access service.

5.5.1. OPEX flow

The OPEX flow is the simplest as foundation holds all fees in a deposit. When there is a need for maintenance or operations in a FONN section, foundation will pay to a maintainer from this OPEX deposit. From this OPEX deposit, foundation also pays to third parties related to FONN costs such as rental costs, insurances, taxes, marketing...

5.5.2. CAPEX flow

The CAPEX flow, which is also related to the ownership flow, is somehow more complicated. We define both flows with the Algorithm 1.

We define it with algorithmic orientation in order to be able to implement it as an event-based model and also to clearly depict the relationships between members. In this event-based model, a computation of the algorithm could correspond to one state change in the FONN ownership or in the foundation resources. For simplicity, and without losing generality, we use a simple interest formula with interest rate G . Furthermore, we add an extra parameter P for the purpose of transferring CAPEX from other FONN sections. In order to clearly state the flow viability restriction, we separate as input parameters the builder deployment cost B , the new user CAPEX U , the new investor's capital C , the pending investor value I , and the promoter CAPEX deposit P .

On the one hand, the flow starts when an investor wants to deploy new FONN he pays all the invested capital (C) to a builder (B). Foundation registers this operation value as an ownership percentage of investor inside mixed FONN license, which we call pending investor value (I'). This operation value is computed as the invested capital (J) plus an agreed profit (G). Note that anyone can be an investor for FONN, although usually they will be providers interested in building trunks or users that need or want to overcome the starting CAPEX. For this reason we remark in Fig. 3 the $>$ CAPEX fee value (see Section 5.2) to show that users cannot replace their fees by investments. Also note that an investor cannot invest C more than the needed builder value B , that is to say that all the capital goes to deploy new network and cannot be used for returning investments nor for generating surplus.

On the other hand, the flow starts from the point where an user has paid the CAPEX fee or where foundation has received donations. Let this starting CAPEX plus donations be what we call *new CAPEX* (U).

Algorithm 1 CAPEX and ownership flow

Input

B = new builder deployment cost
 U = new CAPEX (user starting fee + donations)
 C = new investor's capital
 G = investment profit percentage
 F = foundation ownership value ▷ related to ownership %
 I = pending investor value ▷ related to ownership %
 P = promoter CAPEX deposit

Output

F', I', P' updated values

Let:

$A \leftarrow U + P$ ▷ CAPEX (available)

Require: $(C = 0 \wedge A \geq B) \vee (C > 0 \wedge A + C = B)$

U transfers from user
 C transfers from investor
 B transfers to builder
 $Z \leftarrow I + C \times G - A + B$ ▷ capital or surplus

if $Z \leq 0$ **then** ▷ Full scenario

if $I > 0$ **then** ▷ transition from mixed

I transfers to investor

end if

$F' \leftarrow F + B + I$

$P' \leftarrow -Z$ ▷ surplus variation

$I' \leftarrow 0$

else ▷ Mixed scenario

if $I - Z > 0$ **then** ▷ investment return

$I - Z$ transfers to investor

end if

$F' \leftarrow F + A$

$P' \leftarrow 0$ ▷ transition from full

$I' \leftarrow Z$ ▷ capital variation

end if

return F', I', P'

First, the available CAPEX (A) for deploying new FONN is the new CAPEX (U) plus the CAPEX deposit (P) that a promoter wants to add. This available CAPEX (A) will be transferred to a builder (B) in order to deploy new FONN and foundation will have the ownership (F') for this new FONN section. There is a requirement that this available CAPEX A must be greater than the builder's invoice B , as foundation should not take bank loans.

Second, if the available CAPEX A is greater than the new deployment invoice B , then there is a potential surplus. If there is mixed FONN it means that there are investors pending a return of investment I , so this potential surplus must be transferred to investors and at the same time the same value is also interchanged from investor ownership percentage to foundation ownership percentage, which is some of I' value transferring to F' .

Third, when potential surplus has not totally been returned to investors then this rest is an actual surplus. The promoter for this FONN section increases this surplus in his CAPEX deposit (P'). Note that at the same time, the promoter's CAPEX deposit P value that was used as available CAPEX A must be decreased in P' .

At any time ownership percentages are computed as $\frac{I'}{I'+F'}$ for investor and $\frac{F'}{I'+F'}$ for foundation. I' is the total value (capital build + profit) that an investor has invested as mixed FONN license, which is the same value he is pending for investment return. F' is the total capital value foundation has build. Moreover foundation owns P value which is the CAPEX deposit pending for promoters decisions where to build new network.

Note that there could be multiple users, promoters, and investors, therefore in the algorithm we should distinguish between U_a , P_b , C_c , I_c where $a, b, c \in \mathbb{N}$. However, for simplicity, we have only noted one of each.

Also for simplicity, in the algorithm and in Fig. 3, we have not depicted public administration's role. It is a mix of foundation and investor, that means it has two ownership percentages deposits: one for the investments pending return and another for the FONN it keeps ownership.

Finally, it must be noted that the algorithm is computed separately for each FONN section, as has been defined in Section 5.3. This is remarkable for investment returns, investors will not get return when they have invested in FONN sections that get no users. However, promoters can interchange CAPEX deposit from one FONN section to an other.

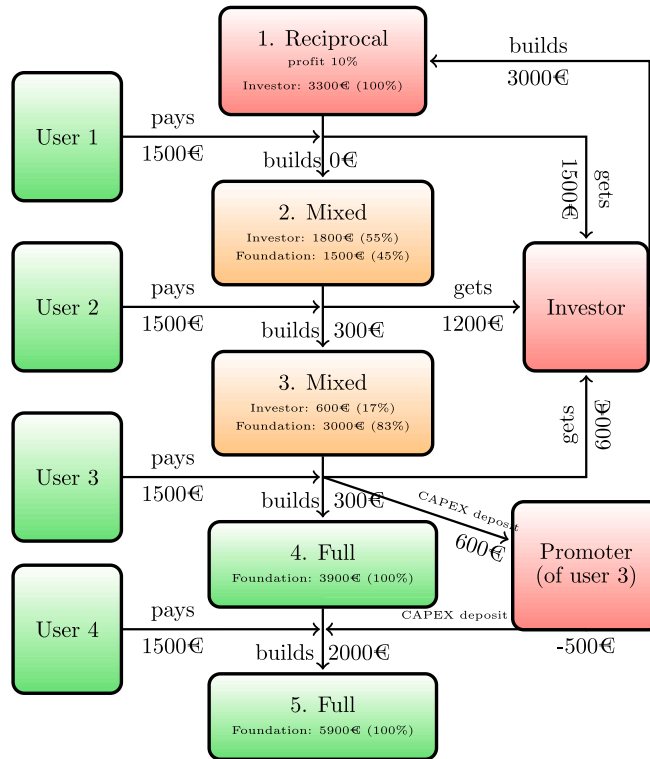


Fig. 4. Example of a FOWN section ownership and FOWN license evolution.

5.6. Example

Once we have defined the new FOWN business model, we exemplify it with a practical case that shows an expected evolution of ownership and FOWN license along time for a particular FOWN section. This example is depicted in Fig. 4 and has five steps.

First, this new FOWN section starts when an investor builds 3000€ of new network, let us assume that there is a builder which has not been depicted. As investor owns the 100% the new FOWN section starts as a reciprocal FOWN license. However, assume he has agreed with foundation a future total profit of 10%, therefore the capital plus profit value annotated for investor is 3300€.

Second, a user pays the 1500€ CAPEX fee and assume there is no need for building new network. Then all the 1500€ go to investment return. Therefore the ownership flow interchanges 1500€ from investor to foundation and the FOWN section gets mixed FOWN license.

Third, a second user pays the 1500€ CAPEX fee and assume that he needs to build a drop of 300€. Then this 300€ increases the foundation ownership and the rest 1200€ go to investment return. Therefore the ownership flow interchanges 1200€ from investor to foundation.

Fourth, a third user pays the 1500€ CAPEX fee and assume that he needs to build a drop of 300€. Then this 300€ increases the foundation ownership and 600€ go to investment return, as it is the last pending investor's value. Therefore foundation owns the 100% and the FOWN section gets full FOWN license. There is a 600€ surplus which go to CAPEX deposit for the promoter of the user.

Fifth, a fourth user pays the 1500€ CAPEX fee and assume that he needs to build a drop of 2000€. As it is not enough, a promoter adds 500€ from his CAPEX deposit. Therefore, foundation ownership value increases by 2000€ and 100€ remain in CAPEX deposit.

Summarizing, the final balance is that users have paid 6000€, the FOWN section builder costs are 5600€, the investor has earned a profit of 300€, and there are still remaining 100€ in CAPEX deposit for building new network. And the FOWN section is at full FOWN license.

6. Case study: Viladordis

The *guifi.net* project is actively being deployed. In this section we examine a particular case where we have applied the new FOWN business model defined in this paper. As a declaration of interest we must notice that one author of this paper resides on the zone being analyzed and also has been the social leader for the *guifi.net* project in this FOWN section.

The localization for the case study is a small neighborhood called *Viladordis*, of about 300 inhabitants. *Viladordis* belongs to a city —about 3 kilometer distance— *Manresa*, in *Catalonia*, of about 80000 inhabitants. Even though being so near from a large city, the area is sparsely populated and did not enjoy a good Internet quality connection as it was provided over copper telephone lines which caused a high signal attenuation.

Firstly, in order to attend this lack of Internet, a wireless broadband network was deployed to the FONN section which connected to *Manresa* and surroundings *guifi.net* facilities. It was built and maintained by surrounding volunteers organized into an association called *Associació Guifibages*. It was in 2010 at the starting of *guifi.net* and, as previously explained, there was no compensation economical system but a crowdfunding building (about 200€ per household) and a best-effort volunteering maintenance.

The impressions for the wireless broadband Internet quality were acceptable as the inhabitants enjoyed connections of about 50 Mbit/s, however there was a high latency especially when there were many wireless broadband hops. A high latency yielded bad user experience for the modern necessities in video calls and in live streaming. For the rest of use cases it posed no problem and there was enough bandwidth.

Regarding the maintenance, it posed a major drawback to be achieved as volunteers. There were a variety of problems: wind turning antennas, devices misconfigurations, normal degradation by devices being outside... To summarize, they were cheap repair works and replacing devices was also cheap, but too much frequent to be served by volunteers.

Secondly, professional maintainers and providers were attracted to the *guifi.net* project, which improved the network maintenance. However, they did not participated fully for the *Viladordis* FONN section as its about 20 users were associated mainly to the nonprofit *Associació Guifibages*. Then each household contributed about 8€/month for OPEX expenses and the surplus were kept as reserve funds for extensions.

Thirdly, it seemed that with a fiber network more quality would be achieved. Although many commercial ISPs deployed fiber in *Manresa*, no one was interested in reaching *Viladordis*. In 2015 the 20 neighbors with *guifi.net* wireless broadband decided to deploy fiber to connect from the *guifi.net* POP, about 10 kilometer distance. In the end there has been a total of 40 neighbors.

The network is deployed upon the new FONN business model concepts defined in this paper. The overall budget has been 53000€ for deploying the trunk fiber plus the drops, some aerial and some underground. Each of the 40 users has payed a CAPEX fee of 1500€ to *Fundació guiifi.net*, from which they have been able to achieve tax benefits according to the Spanish law for foundation donations. It must be noted that some drops were deployed for remote farm houses which spent more than the fee, however it was compensated by other cheaper drops.

As *Associació Guifibages* was the only promoter for the FONN section deployment, the FONN has attained a full FONN license. However, it has been only achieved for the last FONN section. The first 10 km trunk fiber, including the OLT, were shared with another provider by a reciprocal FONN license. Nowadays, this provider has quit the FONN so this first 10 km plus the OLT are a rented private network.

Regarding initial deploying costs, the total CAPEX received ($40 \times 1500 = 60000\text{€}$) was bigger than the overall budget; note that the first 10 km were not payed because they became a private network. Generally speaking, we can conclude that the 1500€ fee was adequate. From now on, this fee could be reduced for new users or allow them to pay it gradually by a 17€/month fee. However, the former is not reasonable as the fees would become independent in each FONN section. It is better to have uniform fees within a big region —i.e. a country— as then all the members perceive they belong to the same FONN and, in addition, the CAPEX deposit can jump between FONN sections.

Regarding the maintenance, until now there have only been a few tasks. On the trunk part a rat ate underground cables and a tractor overthrew aerial cables. On the drop parts, which is the riskiest for breakdowns, two users have broken the fiber cable inside their home. Although these repair works have been expensive they all have been achieved enough by the 6€ OPEX fee.

Summarizing, the fiber has initial high building costs but affordable by a few users. Regarding the maintenance the long-term costs are similar for fiber and wireless broadband, however for fiber they are more expensive and less frequent. Finally, after some years of the *Viladordis* FONN fiber deployment, two ISPs have also deployed their own network, that is to say that now there are three duplicated fiber networks for a neighborhood of 300 inhabitants.

At the same time of the successful deployment in *Viladordis*, we generalized the model for the *guiifi.net* case. We elaborated the business model of this paper by discussing with some of the *guiifi.net* members. Particularly we attended the commercial ISP restlessness in order to overcome them with the new model. The model basic ideas were approved by *Fundació guiifi.net* in an assembly with community and commercial ISPs. However, the ISPs that owned the majority of the *guiifi.net* FONN quit the project before the new model was implemented. After these ISPs have left, *guiifi.net* has suffered a collapse and the model has not been able to be implemented globally yet.

After this experience, we think the FONN business model could inspire applications in other technologies or even other areas. As an example of other areas, building and maintaining a community road network might make sense in a region where there is a lack of public infrastructure. However, it is more feasible to apply this model to network communication technologies. Besides cellular networks, LPWAN networks are in increasing demand in line with the growth of IoT devices. For instance, *XOIC* [22] is an initiative that uses *LoRaWAN* to build an open network for IoT. This type of network has the advantage that the registration of new users to the community is a simple process in which no new infrastructure is needed. Although deploying infrastructure like this is simple compared to fiber, there is still the challenge of maintaining a significant number of gateways, even more so considering the potential saturation of the spectrum due to the exponential growth of IoT devices. This is one of the reasons why LPWAN networks can benefit from the proposed FONN business model, in which member roles are clearly stated.

7. Conclusion

In this paper we have settled the FONN with the free software and with the tragedy of the anticommons. Particularly we have pointed the *guifi.net* FONN context and concluded that FONN has the following strengths:

- The FONN manifesto states the freedoms that must be granted to users in order to keep network open, free, and neutral.
- The network topology and the current available fiber/wireless network technology makes it easy to share resources and infrastructure.
- It spreads everywhere, including rural areas and sparsely populated areas.
- It contributes to avoid the tragedy of anticommons because it shares and does not duplicate network infrastructure nor maintenance efforts.

The proposed business model has the following properties:

- Members roles are defined independently.
- As a novelty, the economic compensation system has been defined as a formal algorithm that states CAPEX, OPEX and ownership flows, where fees are fixed and focused on user.
- Different ownership FONN licenses are proposed: full, mixed, and reciprocal.

These properties overcome some previous FONN weaknesses, allowing the move from wireless to fiber technology, as we have successfully demonstrated in the fiber deployment of the Viladordis FONN section.

However, there are still some points that are beyond the scope of this document. First, alternatives to fixed fees, such as variable fees, could be discussed. Second, all members must be properly represented in the foundation's governance. For example we have noted the need for a *network council* to decide fees. Third, the business model in this paper should be assembled in legal agreements encompassing territorial scope for different countries.

CRedit authorship contribution statement

Alex Llusà Serra: Writing – original draft. **Francisco del Àguila López:** Writing – original draft. **Jordi Bonet Dalmau:** Writing – original draft. **Xavier Moncunill-Geniz:** Writing – original draft.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The authors know deeply *guifi.net* as they are members with three roles. One, they are users as their home Internet is provided by FONN. Two, they are providers as members of a community-owned nonprofit ISP: Associació Guifibages. Three, they are volunteer maintainers for a FONN section in Bages, Catalonia.

Data availability

No data was used for the research described in the article.

Acknowledgments

The authors would like to thank Fundació *guifi.net* and the rest of *guifi.net* members.

References

- [1] Free Software Foundation, What is free software? The four essential freedoms, 1996–2022, URL <https://www.gnu.org/philosophy/free-sw.html.en>.
- [2] Fundació *guifi.net*, The compact for a free, open & neutral network (FONN compact), 2014, Original in catalan (2009): <https://guifi.net/ComunsXOLN>.
- [3] European Union, Regulation (EU) 2015/2120 [...] laying down measures concerning open internet access and retail charges for regulated intra-EU communication, 2015, URL <https://eur-lex.europa.eu/eli/reg/2015/2120/2020-12-21>. Official Journal of the European Union.
- [4] P. Micholia, M. Karaliopoulos, I. Koutsopoulos, L. Navarro, R. Baig, D. Boucas, M. Michalis, P. Antoniadis, Community networks and sustainability: A survey of perceptions, practices, and proposed solutions, *IEEE Commun. Surv. Tutor.* 20 (4) (2018) 3581–3606, <http://dx.doi.org/10.1109/COMST.2018.2817686>.
- [5] Fundació *guifi.net*, *guifi.net*. Commons telecommunications network open, free and neutral, 2004–2022, URL <https://guifi.net/en>.
- [6] Freifunk, Freifunk, a non-commercial initiative for free wireless networks, 2013–2023, URL <https://freifunk.net>.
- [7] Ninux, Ninux.org, wireless network community, 2000, URL <http://ninux.org>.
- [8] Freifunk, Pico peering agreement, 2002, URL <http://picopeer.net>.
- [9] Z. Sherbrooke, ZAP, non-profit wireless network for providing gratis internet access points, 2021, URL <http://zapshebrooke.org/>.
- [10] L. Belli (Ed.), *Community Networks: The Internet by the People, for the People*, Escola de Direito do Rio de Janeiro da Fundação Getulio Vargas, Rio de Janeiro, 2017, ISBN: 978-85-9597-010-6.
- [11] European Commission, Summary report on the results of the exploratory consultation on the future of the electronic communications sector and its infrastructure, 2023, URL <https://digital-strategy.ec.europa.eu/en/library/results-exploratory-consultation-future-electronic-communications-sector-and-its-infrastructure>.
- [12] E. Duparc, F. Möller, I. Jussen, M. Stachon, S. Algac, B. Otto, Archetypes of open-source business models, *Electron. Mark.* 32 (2) (2022) 727–745, <http://dx.doi.org/10.1007/s12525-022-00557-9>.

- [13] J. Koenig, Seven open source business strategies for competitive advantage, *IT Manag. J.* (2004) 1–6, URL http://riseforth.com/pdf/seven_open_source_business_strategies.pdf.
- [14] Plone Foundation, Contributor's agreement for plone explained, 2004–2022, URL <https://plone.org/foundation/contributors-agreement>.
- [15] R. Baig, R. Roca, F. Freitag, L. Navarro, guifi.net, a crowdsourced network infrastructure held in common, *Comput. Netw.* 90 (2015) 150–165, <http://dx.doi.org/10.1016/j.comnet.2015.07.009>.
- [16] R. Baig, L. Dalmau, R. Roca, L. Navarro, F. Freitag, A. Sathiaselan, Making community networks economically sustainable: The guifi.net experience, in: Proceedings of the 2016 Workshop on Global Access to the Internet for All, ACM SIGCOMM, GAIA '16, ACM, Florianopolis, Brazil, 2016, pp. 31–36, <http://dx.doi.org/10.1145/2940157.2940163>.
- [17] R. Baig, F. Freitag, L. Navarro, Cloudy in guifi.net: Establishing and sustaining a community cloud as open commons, *Future Gener. Comput. Syst.* 87 (2018) 868–887, <http://dx.doi.org/10.1016/j.future.2017.12.017>.
- [18] J.M. Buchanan, Y.J. Yoon, Symmetric tragedies: Commons and anticommons, *J. Law Econ.* 43 (1) (2000) 1–14, <http://dx.doi.org/10.1086/467445>.
- [19] M.A. Heller, The tragedy of the anticommons: Property in the transition from Marx to markets, *Harv. Law Rev.* 111 (3) (1998) 621–688, <http://dx.doi.org/10.2307/1342203>.
- [20] Fundació guifi.net, Fundació guifi.net. We promote the deployment of a shared telecommunications network, 2008–2022, URL https://fundacio.guifi.net/en_US/.
- [21] L. Cerdà-Alabern, R. Baig, L. Navarro, On the guifi.net community network economics, *Comput. Netw.* 168 (2020) 107067, <http://dx.doi.org/10.1016/j.comnet.2019.107067>.
- [22] femProcomuns, XOIC and TICAE LoRaWAN network server deployed in Catalonia, 2024, URL <https://femprocomuns.coop/la-xoic-i-ticae-creen-un-servidor-de-xarxa-lorawan-obert-a-catalunya/?lang=en>.

Glossary

AP: access point as a hub routing to other APs interconnected in a tree fashion with some ring connections for redundancy purposes

builder: deploys new trunks, drops, OLTs, ONUs, APs...

CAPEX: building infrastructure starting fee

CAPEX deposit: register where foundation holds how much CAPEX surplus can spend each promoter

CATNIX: nowadays the only IXP for *guifi.net*

CTO: core fiber optic terminal boxes

drop: from CTO to ONU

fee: fixed price that each user must satisfy to cover all FONN costs

fiber: fiber optic telecommunications usually on point to point or PON architectures

FONN: free, open, and neutral network

FONN license: three types of license regarding FONN ownership: full, mixed, and reciprocal

FONN manifesto: the agreement that enunciates the four freedoms and other requirements for FONN

FONN section: the network can not be seen as a whole, then FONN licenses apply to each section

foundation: the nonprofit governance for the FONN

free, open and neutral network (FONN): all the Internet subnetworks worldwide under the FONN manifesto

full: when the FONN owners are only foundations or public administrations

Fundació guifi.net: the foundation that governs *guifi.net* [20]

guifi.net: actually the largest known FONN [5]

internet exchange point (IXP): the neutral location where the external Internet traffic is exchanged through peering with other ISPs or through network service providers (*carriers*)

internet service: whichever product a provider offers to an user at a monthly rate

internetworking: the network operation centre located in an IXP

investor: purchases new FONN deployments and expects the return of all the investment plus a profit but with total capital risk

IP 10.X: private IP in the 10.0.0.0/8 range

ISP: internet service provider

IXP: internet exchange point

last mile: the access network that connects POPs to final users

maintainer: repairs, changes, maintains and operates the network

member: all the people around the FONN

middle mile: connects the internetworking to last mile POPs, nowadays it is deployed over third parties so it is also called *regional transport*

mixed: when the FONN owners are foundations, public administrations, and investors

OLT: optical line terminal the service provider endpoint

ONU: optical network unit the final device for users

OPEX: maintaining and operating monthly fee

PON: passive optical network fiber technology

POP: each of the regional local access point of presence

promoter: manages the CAPEX surplus he has achieved by persuading users or investors

provider: an ISP inside the FONN who offers internet services to users

public administration: an investor that can keep the network ownership alike foundation

reciprocal: when the FONN owners are only investors and they establish reciprocity with the FONN manifesto

STA: station final device for users

trunk: from OLT to CTO

user: uses the FONN as a communications network, respecting the FONN manifesto

wireless broadband: high-speed fixed wireless networking usually on unlicensed bands